

**REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT**

(Hobart, Australia, 8 to 17 October 1991)

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### **INTRODUCTION**

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at the CCAMLR Headquarters, Hobart, Australia from 8 to 17 October 1991. The Convener, Dr K.-H. Kock (Germany) chaired the meeting.

1.2 The Convener welcomed participants to the meeting. Several intending participants had not arrived for the start of the meeting. It was therefore adjourned for a day in anticipation of their arrival and also to allow participants time to read all the tabled papers.

### **GENERAL MATTERS AND APPOINTMENT OF RAPPORTEURS**

2.1 A List of Participants is given in Appendix A.

2.2 The following were appointed rapporteurs:

Dr I. Everson (UK), Agenda Items 1 to 6;  
Conveners of Assessment Groups, Agenda Item 7; and  
Dr D. Agnew (Secretariat), Agenda Items 8 to 11.

2.3 In accordance with a decision reached last year, all papers delivered to the Secretariat prior to the start of the meeting were accepted as working papers. Due to unforeseen travel difficulties, Drs K. Shust and P. Gasiukov (USSR), both of whom had notified their intention to participate in the meeting, were unable to be present at the start. They had informed the Secretariat that they intended to table several papers but copies had not been received by the deadline. Copies of four of these papers had been received by the Convener and he tabled them on behalf of Drs Shust and Gasiukov. One further USSR paper was only available as a summary and abstract. This was accepted in this abbreviated form (WG-FSA-91/23) even though participants had no information with which to clarify the method or substantiate the figures presented.

2.4 The Working Group re-emphasised its decision of the last meeting namely, papers should be submitted in a complete form rather than a summary and:

- papers that arrive at the Secretariat later than the day before the meeting will not be considered at that meeting; and
- the deadline for submission of papers for consideration at the meeting will be re-named ‘the recommended date for submission’. Papers submitted by this date will be distributed prior to the meeting.

## ADOPTION OF THE AGENDA

3.1 The adopted Agenda is attached as Appendix B, and a List of Documents presented to the meeting is attached as Appendix C.

## THE CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION

4.1 WG-FSA emphasised the need for a scheme of international scientific observation for the collection of data. The deployment of observers would improve data collection generally and some data, essential for WG-FSA assessments, could only be collected in this way. It was stressed, however, that data collected under the scheme would not be a substitute for fisheries data requested from Members.

4.2 Discussion centred on two aspects of the scheme: firstly on practical aspects of the implementation of the scheme; and secondly on the technical details of the information that is required.

4.3 Concern was expressed that the amount of work requested of observers should not exceed the amount reasonably to be expected from individuals working at sea. It was agreed that a list of priority observations should be drawn up to assist observers with making decisions concerning data collection. This proposed list of priority observations, along with explanations, would need to be included in an observer’s manual.

4.4 Decisions on the priority to be assigned to different aspects of the observation program will need to be made based on several criteria such as, whether:

- (i) the stock under consideration was considered to be particularly vulnerable and was one for which only limited information was available;
- (ii) the information needed from the fishery was considered vital for WG-FSA to undertake assessments;
- (iii) there are critical uncertainties that might be clarified by observations at sea; and
- (iv) the only reasonable way to collect the data was from observations at sea.

4.5 Consideration needs to be given to the organisation of individual components of the observation scheme because while some topics might be addressed adequately by a limited series of observations, others might require a more or less continuous series over many years.

4.6 The Working Group agreed that haul-by-haul data should be collected as a routine activity. Furthermore it was considered that activities under the scheme, for the time being, should be allocated to fisheries in the following order of priority:

- (i) *Champsocephalus gunnari*;
- (ii) longline fishery for *Dissostichus eleginoides*;
- (iii) by-catch of juvenile fish in the krill fishery; and
- (iv) *Electrona carlsbergi*.

4.7 Observations from the *C. gunnari* fishery were assigned the following priorities:

- (i) representative length frequency distributions;
- (ii) observations on sex and maturity stage;
- (iii) collections of otoliths for age determination;
- (iv) observations on by-catch species; and
- (v) the incidental mortality of predators (birds and seals).

4.8 Observations from the *D. eleginoides* longline fishery were assigned the following priorities:

- (i) representative length frequency distributions;
- (ii) observations on sex and maturity stage;
- (iii) incidental mortality of avian predators due to longline fishing; and

- (iv) loss rate of fish from hooks; catching efficiency of different hook sizes and types; observations on the condition of fish on capture (for tagging experiments).

4.9 The major priority for observations of by-catch of juvenile fish in the krill fishery is to examine sub-samples of the catch and to obtain specimens of individual fish. A lower priority for observations would be to obtain qualitative information on fishing conditions such as krill swarm size, depth and degree of aggregation, when juvenile fish were most prevalent in the catches.

4.10 The major priorities for observations on *E. carlsbergi* would be to describe how the fishery operates and also to determine whether there was a significant by-catch of other species. Although an observer would be expected to collect biological data from this fishery these data were not considered to be critical for stock assessment at the present stage.

4.11 Following the 1991 meeting of the Working Group on Krill (WG-Krill), the Secretariat had prepared draft formats for use by observers on commercial fishing vessels (SC-CAMLR-X/8). The paper presented a series of draft forms for the collection of data from all fisheries. These are included here as Appendix D.

4.12 The proposed scheme is designed to operate in a hierarchical form. The top format in this scheme is Format 0 which provides the Observer Summary Information; below this are formats related to the krill, finfish (trawls) and finfish (longline) fisheries.

4.13 Format 0 (Observer Summary Information) was considered essential as it contains key information for the other formats. Additional specific points for inclusion in this format were:

- (i) provision for recording a range of different activities such as: fishing, searching, transit, vessel stationary, etc.;
- (ii) an indication as to whether the fishfinder was operational;
- (iii) reporting of time in a standard form such as GMT; and

(iv) an indication of position fixing equipment type (e.g. satellite navigator, GPS\*).

4.14 It was recognised that obtaining this information would entail a great deal of work on the part of the observer. Much of the information would, however, be available from the ship's logbook.

4.15 Formats 1, 2 and 3 relate to the krill fishery and were not discussed by WG-FSA.

4.16 Format 4 relates to observation on predators. It was felt that provision should be made for the incorporation of the following information on type of predator activity with respect to the vessel operations:

- (i) aggregation of predators in the area of fishing operations; and
- (ii) predators interacting with fishing gear.

4.17 Format 5 concerns length, sex and maturity of finfish. WG-FSA agreed that the format for length frequencies should include categories for immature as well as male and female fish. Maturity stages could be included into a table of similar structure to the length frequency table. These tables could also include mean weights for each category. The format should also make provision for information concerning the collection of scales and otoliths for age determination.

4.18 Information on the age of fish cannot be collected by observers during routine work at sea, and, if this item is excluded, most of Format 6 becomes redundant. Information on mean weights can be incorporated into Format 5 as outlined above.

4.19 Format 7 provides for the collection of data from longline fishing. The length composition in the catch is highly dependent on the hooks used in the fishery (WG-FSA-91/11). It was agreed that hooks should be specified in terms of brand name, pattern and size number.

4.20 The Secretariat was requested to redraft the proposed reporting formats in the light of comments made at the meeting.

4.21 To facilitate consistent methods of data collection WG-FSA agreed that a manual should be produced to provide precise protocols for data collection. Some ideas for inclusion

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\* Global Positioning System

in such a manual are outlined in SC-CAMLR-X/8. WG-FSA made the following further points for inclusion in a revised form:

- (i) sampling commercial fish species: change from '30 fish' to 'a representative sample'; and
- (ii) otolith and scale sampling: samples of otoliths or scales from at least five fish should be taken from each size class.

4.22 The Secretariat was thanked for preparing the draft formats and protocol for discussion and, in consultation with Drs G. Duhamel (France), M. Vacchi (Italy), Kock and Shust, was requested to prepare a manual to be distributed to observers. The manual for observers in the Kerguelen fishery would provide a helpful example.

## APPROACHES TO CONSERVATION

### New and Developing Fisheries

5.1 In response to questions raised at the 1989 meeting of the Commission, the Working Group in 1990 outlined the types of information that would be necessary to provide advice on the management of new and developing fisheries.

5.2 The Working Group identified the following information that would be required for it to assess the initial catch level (SC-CAMLR-IX, Annex 5, paragraph 289):

- ‘(i) biological information from comprehensive research/survey cruises, such as distribution, abundance, demographic data and information on stock identity;
- (ii) details of dependent and associated species and the likelihood of them being affected in some way by the proposed fishery;
- (iii) the nature of the proposed fishery, including target species, methods of fishing, proposed region and any minimum level of catches that would be required to develop a viable fishery; and
- (iv) information from other fisheries in the region or similar fisheries elsewhere in the world that may assist in the evaluation of potential yield.’

5.3 Also at the 1990 meeting of the Working Group it was proposed that (SC-CAMLR-IX, Annex 5, Appendix D, paragraph 27):

‘Members who intend to start a fishery should provide CCAMLR with the following information:

- the proposed fishing operation, including target species, methods of fishing, proposed region and any minimum level of catches that would be required to develop a viable fishery; and
- details of the stock size, abundance, demography (e.g. growth parameters, size and age at sexual maturity).’

5.4 The Working Group felt that this remains a valid summary of the information requirements and noted that the Commission, at its last meeting, had begun consideration of a draft conservation measure for the regulation of new fisheries which included these requirements.

5.5 Discussion of the draft conservation measure is to be continued at the 1991 meeting of the Commission with initial attention focussing on suitable definitions for new and developing fisheries.

5.6 The Working Group felt that different types of new fisheries could be defined in terms of the target species, the location of the fishery and the type of fishing gear to be used. Using the definition prepared by the Secretariat in CCAMLR-X/6, the Working Group recommended the following definitions:

A new fishery is a fishery on a species using a particular fishing method in a statistical subarea for which:

- (i) information on distribution, abundance, demography, potential yield and stock identity from comprehensive research/surveys or exploratory fishing have not been submitted to CCAMLR;  
or
- (ii) catch and effort data have never been submitted to CCAMLR;  
or



- (iii) catch and effort data from the most recent two fishing seasons have not been submitted to CCAMLR.

#### Interaction of other Components of the Ecosystem (e.g. Birds, Mammals) with Fisheries

5.7 Evidence was presented that significant mortality of flying birds is being caused by trawl fisheries in the Kerguelen Islands area (SC-CAMLR-X/BG/14) and in the sub-Antarctic trawl fishery on squid conducted by Soviet vessels under agreement with New Zealand (SC-CAMLR-X/BG/4). The effect was such that if there are not changes in the New Zealand squid trawl fishery, it was estimated that the NZ white-capped albatross could become extinct within the next 32 years.

5.8 There is likely to be a problem of bird mortality wherever there are high concentrations of seabirds associated with trawl fisheries. The main cause of mortality is due to the birds flying into and being hit by the netsonde cable when it whips up and down due to the pitching of the fishing vessel. The effect is greatest whilst the net is being hauled. The birds do not see the cable because they are concentrating on trying to catch fish escaping from the net. The greatest effect is likely to be in fisheries targetting smaller fish species such as *C. gunnari* and Myctophidae.

5.9 Recent technological advances have meant that, for many, but not all operations, netsounders operating by an acoustic link are available. These types of netsounder, having no direct cable link from the transducer to the ship, do not cause injury to birds. It was suggested that the cost of changing from a cable system to an acoustic system might be too expensive for some operators. WG-FSA considered ways that netsounder cables might be modified to minimise injury to birds. It was suggested that a larger diameter cable or one fitted with high visibility streamers might be effective. These modifications would cost money and, in the long term, might be similar to the cost of a system operating through an acoustic link.

5.10 The Working Group agreed that wherever possible in commercial fisheries the use of netsonde cables should be phased out.

5.11 A further cause of mortality to flying birds is due to the birds taking the baits from longlines (SC-CAMLR-X/BG/14). It is known that this can be reduced by the use of a 'tori' pole (CCAMLR-IX/BG/14 Rev. 1) but there is no indication that this equipment has been used in longline fisheries within the CCAMLR Convention Area.

## Prey Requirements for Krill Predators

5.12 WG-FSA noted that the Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) is undertaking an analysis of prey requirements for krill predators (Annex 7, paragraphs 6.1 to 6.26). Krill is a significant component in the diet of many fish species and WG-FSA felt that predation on krill by fish ought to be included in that analysis.

5.13 WG-FSA agreed to investigate predator/prey interactions involving fish for incorporation into the CEMP analysis and requests WG-CEMP to keep it (WG-FSA) informed of developments in this field.

5.14 There is evidence that in some years (e.g. the 1990/91 season and possibly the 1977/78 and 1983/84 seasons) the presence of *Euphausia superba* in the South Georgia subarea has been reduced (WG-FSA-91/29 and WG-CEMP-91/37). In addition to the direct effect on food availability to the fish, this may have the further effect of causing larger predators to switch from krill to fish for food.

5.15 Until now, this information has been largely anecdotal, but the assessment of stocks, especially of *C. gunnari*, in the previous season can be helped in these cases by having details on the diet, foraging range and breeding success of these predators so that some input on the environmental influences on the stocks, as distinct from fishing effects, is available. Such data from the CEMP Program or other sources should be available to WG-FSA for its meetings.

5.16 WG-FSA-91/8 provides information on the daily food intake of nine high-Antarctic fish species which is a crucial parameter in estimating, for example, prey requirements. The Working Group noted the importance of this type of data in taking account of dependent and related species in the formulation of management advice. It recommended that further such studies be undertaken.

## By-Catch of Young and Larval Fish in the Krill Fishery

5.17 Discussion during the 1990 meeting of WG-FSA indicated that there is a potential problem whereby significant numbers of juvenile fish might be taken during commercial fishing operations.

5.18 WG-KRILL-91/25 had indicated that the problem is probably confined to certain localised shelf areas. There are also indications that the problem is least when krill catch rates are highest.

5.19 The problem is likely to be greatest in nursery ground areas for young fish. The region close to the shelf break in Prydz Bay is one where significant numbers of *Pleurogramma antarcticum* occur and also where there has been commercial krill harvesting taking place (WG-FSA-91/35). There is likely to be a significant effect on juvenile channichthyids if the krill fishery extends onto the shelf.

5.20 Notwithstanding the results reported in the two papers referred to above, the Working Group noted that little new information is available on the identification of specific nursery areas for fish. The Commission (CCAMLR-IX, paragraph 4.19) has requested that such areas be identified. At this stage the Working Group felt unable to provide advice on specific locations. The collection of information aimed at identifying fish nursery grounds close to krill fishing areas is urgently required.

## REVIEW OF MATERIAL FOR THE MEETING

### Data Requirements

6.1 Data submissions were incomplete at the start of the meeting and, although some data were provided during the meeting, the data were still incomplete when the analyses were undertaken. Indications of the data submitted and gaps in the dataset are shown in SC-CAMLR-X/BG/2.

6.2 Various data were specifically requested by the Working Group in 1990 (SC-CAMLR-IX, Annex 5, Appendix I). Data submitted to the Secretariat in response to this request are listed in Appendix E.

6.3 Many of the requests of the Working Group had not been addressed. The Working Group noted that the majority of the biological data submitted to the Secretariat had been from research cruises, and reiterated its requirement for biological data from the commercial fisheries.

## Catch and Effort Statistics

6.4 STATLANT data had been received at the beginning of the meeting from all Members known to be engaged in commercial fishing with the exception of USSR who had submitted an interim note of total catch for some species. During the course of the meeting, STATLANT data was submitted by the USSR.

## Size and Age Composition

6.5 Representative size frequency distributions were available from standing stock surveys undertaken at South Georgia and the South Orkneys (WG-FSA-91/14 and 33).

6.6 Data were presented on size composition from the *D. eleginoides* longline fishery of the USSR and from the Polish trawl fishery, both in Subarea 48.3. No data were available from other commercial fisheries.

## Other Available Biological Information

6.7 The diet composition and feeding intensity of *C. gunnari* around South Georgia in early 1991 are described in WG-FSA-91/29. Both the proportion of krill (*E. superba*) in the stomachs and the feeding intensity were uncommonly low in a period when energy-rich food is needed for the final maturation of the gonads.

6.8 Sexual maturation of *C. gunnari* was studied by macroscopic and microscopic examination of gonads (WG-FSA-91/7). Evidence was presented in support of the hypothesis that a high proportion of mature fish failed to spawn. It is concluded that the underlying cause is probably due to a shortage of krill.

6.9 Genetic population structure of *C. gunnari* in waters from around South Georgia, South Orkneys and Heard Island was examined using allozyme enzyme electrophoresis (WG-FSA-91/22). Compared with 1990, there was a reduction in genetic variation between South Georgia and Shag Rocks. The authors conclude that genetic data 'supports the notion of migration between areas (South Georgia and South Orkneys). Such an assertion must however, be corroborated with additional data at other biological levels'. There are major genetic differences between *C. gunnari* from the Atlantic sector and those of Heard Island.

6.10 The vertical migration of *C. gunnari* was described based on acoustic observations on the South Georgia shelf (WG-FSA-91/6). During daytime the fish are concentrated on the bottom whilst at dusk they migrate into the water column.

6.11 An analysis of longline catches of *D. eleginoides* from the west coast of Chile indicated that the fishery was moving southwards as stocks became depleted. It is suggested that there may be significant mixing of this species over its geographical range from Chile, the Patagonian shelf and South Georgia (WG-FSA-91/10).

#### Mesh/Hook Selectivity and Related Experiments Affecting Catchability

6.12 Studies on catches of *D. eleginoides* indicated that the type and size of hook has a strong effect on the sizes of fish caught (WG-FSA-91/11). Circular hooks appear to be more effective at catching fish although this may be due to this pattern of hook being better able to retain bait and large fish.

6.13 No studies on mesh selection of nets were reported.

#### Assessments Prepared by Member Countries

6.14 Assessments prepared by Member countries are considered in the relevant paragraphs of the assessment section of this report.

#### Standardisation of Survey Trawls

6.15 Comparisons have been made between the trawl nets used during recent surveys around South Georgia (WG-FSA-91/16 and 21). The net used on the *Professor Siedlecki* (P32/36) in 1989 and *Falklands Protector* (FP-120) in 1991 have similar characteristics. The net used by *Hill Cove* (HC-120) had lower wings and probably a wider spread than originally reported which may have caused an overestimation of standing stock.

6.16 No information was available on the nets used during the recent USSR surveys. WG-FSA recommended that calibration of these nets should be undertaken as soon as possible.

6.17 It was suggested that a calibration of the different nets might be obtained by comparison of catches of non-commercial species.

## ASSESSMENT WORK

7.1 Summaries of the assessments presented in the following section are given in Appendix J.

### South Georgia (Subarea 48.3)

7.2 The history of catches taken in the South Georgia subarea is given in Table 1 and Figure 1. The figure demonstrates how fishing has shifted from *Notothenia rossii* which was the target species in the beginning of the fishery, to *C. gunnari* and *Patagonotothen guntheri*\* from the second half of the 1970s and *D. eleginoides* and *E. carlsbergi* from the second half of the 1980s onwards.

7.3 The depletion of a number of stocks, the high variability in recruitment of *C. gunnari*, the establishment of TACs by CCAMLR and the targetting of new species have led to a high variability in annual catches.

7.4 The total catch of all species in 1990/91 was 82 423 tonnes which was twice the catch taken in 1989/90. This was primarily due to a 3.5-fold increase in the catch of *E. carlsbergi* to 78 488 tonnes. This species made up 95% of the total catch in Subarea 48.3.

7.5 Despite a TAC of 26 000 tonnes for *C. gunnari* set by the Commission in 1990 (Conservation Measure 20/IX), only 93 tonnes of *C. gunnari* were taken mostly in research vessel catches. The only known commercial trawl fishing was carried out by a Polish trawler between 22 December and 15 January taking 41 tonnes of *C. gunnari* (WG-FSA-91/36) (see paragraph 7.22).

7.6 Catches of *D. eleginoides* in the longline fishery of 2 394 tonnes were in accordance with the TAC of 2 500 tonnes set by the Commission for the period commencing on 2 November 1990 (Conservation Measure 24/IX).

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\* Based on recent findings, the name has been changed from *Patagonotothen brevicauda guntheri* to *Patagonotothen guntheri* (Dewitt *et al.*, 1990)

Table 1: Catches of various finfish species from Subarea 48.3 (South Georgia subarea) by year. Species are designated by abbreviations as follows: SSI (*Chaenocephalus aceratus*), ANI (*Champscephalus gunnari*), SGI (*Pseudochaenichthys georgianus*) and ELC (*Electrona carlsbergi*), TOP (*Dissostichus eleginoides*), NOG (*Notothenia gibberifrons*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), NOT (*Patagonotothen guntheri*). ‘Others’ includes Rajiformes, unidentified Channichthyidae, unidentified Nototheniidae and other Osteichthyes.

Split year	SSI	ANI	SGI	ELC <sup>e</sup>	TOP	NOG	NOR	NOS	NOT	OTHERS	TOTAL
1970	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	254	0	0	0	0	0	0	0	493	747
1975	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	293	93400	1608	0	441	3357	7945	2937	0	14630 <sup>a</sup>	124611
1978	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	464	641	1104	0	70	2540	2137	0	15011	2738 <sup>b</sup>	24705
1980	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	1272	29384	1661	0	239	7971	1651	544	36758	12197 <sup>c</sup>	9167
1982	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	128194	0	524	116	0	866	0	5029	11753 <sup>d</sup>	146482
1984	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	1	21359	1	29673	4138	838	152	927	13016	55	70160
1990	2	8027	1	23623	8311	11	2	24	145	2	40148
1991	2	92	2	78488	3641 <sup>f</sup>	3	1	0	0	1	82423

<sup>a</sup> Includes 13 724 tonnes of unspecified fish caught by the Soviet Union

<sup>b</sup> Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria

<sup>c</sup> Includes 4 554 tonnes of unspecified Channichthyidae caught by the GDR

<sup>d</sup> Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

<sup>e</sup> Before 1988, it is not confirmed that these were *Electrona carlsbergi*

<sup>f</sup> Includes 1 440 tonnes taken before 2 November 1990

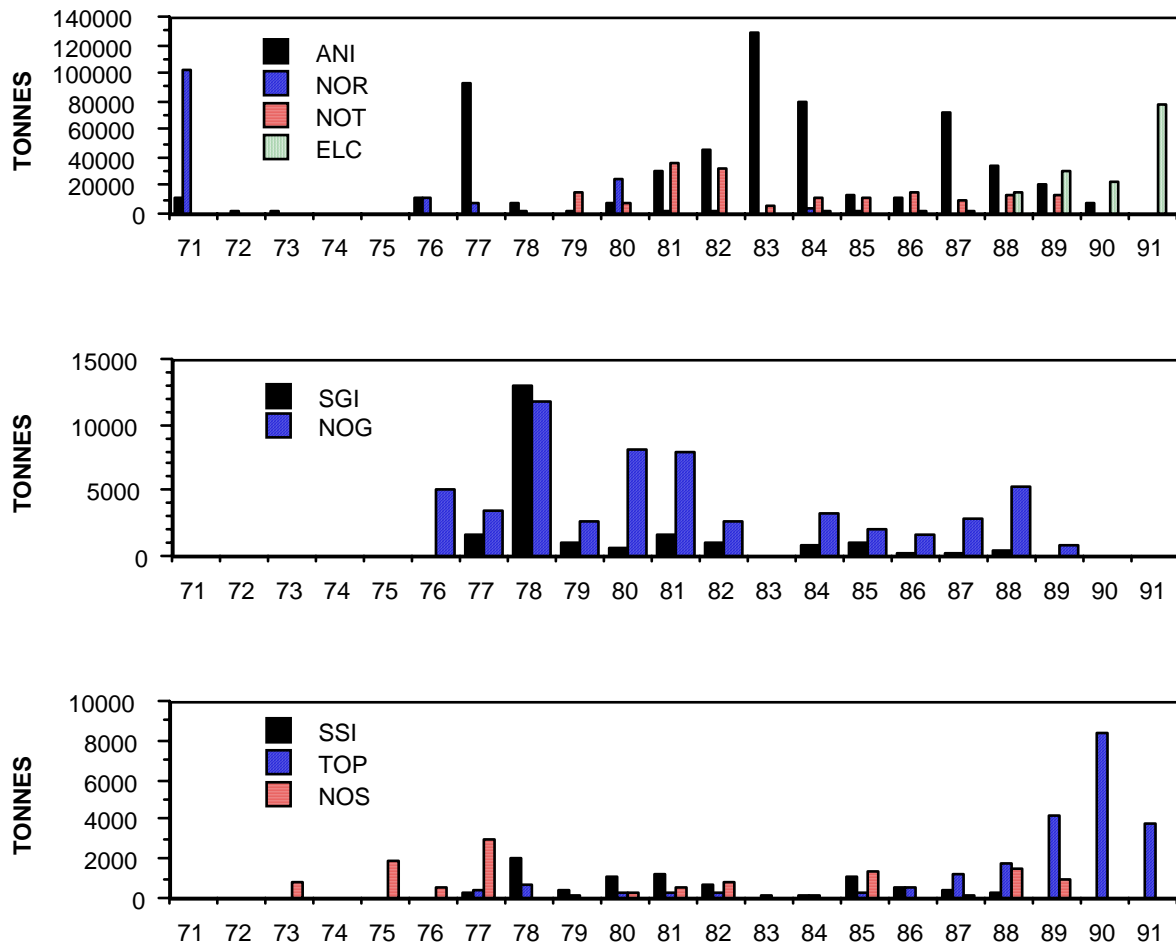


Figure 1: Catches of major species in Subarea 48.3.

7.7 Reported catches of other demersal species, such as *N. rossii*, *Notothenia gibberifrons*, *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus* were in the order of a few tonnes only and originated exclusively from research vessels. Directed fishing on these species was prohibited in 1990/91 (Conservation Measures 3/IV and 22/IX).

#### *Notothenia rossii* (Subarea 48.3)

7.8 This species was severely affected by fishing in the early 1970s. The Commission's conservation measures in force since 1985 (Conservation Measures 2/III and 3/IV) have prohibited fishing of *N. rossii* and aimed to keep the by-catches of the species to a level as low as possible. Reported catch in 1990/91 was only 1 tonne and was unlikely to have been higher due to the absence of commercial trawling in the subarea.



7.9 Length compositions from research vessel catches (*Falklands Protector* and *Atlantida*) did not exhibit significant differences to previous years, i.e. length compositions consisted mostly of 40 to 65 cm fish with mean lengths of 50 to 53 cm (WG-FSA-91/23 - see paragraph 2.3 above, and WG-FSA-91/14). Biomass estimates from these two surveys were 4 295 tonnes (CV 49%) and 10 022 tonnes (CV 57%), which was in the range of biomass estimates from previous seasons. This suggests that the stock remains at a low level.

#### Management Advice

7.10 In view of the current low level of the stock of *N. rossii*, all conservation measures for this species should remain in force.

#### *Patagonotothen guntheri* (Subarea 48.3)

7.11 Conservation Measure 23/IX prohibited directed fishing on this species in the 1990/91 season. No catch of *P. guntheri* has been reported to CCAMLR.

7.12 Two new biomass estimates from bottom trawl surveys were available to the Working Group:

Period	Biomass (tonnes)	CV%	Source
Jan/Feb 1991	584	45	WG-FSA-91/14
Apr/May 1991	16 365	32	WG-FSA-91/23 (see paragraph 2.3 above)

The biomass estimate varied by an order of magnitude. The CV of the April/May 1991 estimate appears to be comparatively small, but variation was very high in the depth stratum in which *P. guntheri* is known to be most abundant (50 to 150 m). However, due to the benthopelagic mode of life of this species, the Working Group reiterated findings from assessments in previous years that any biomass estimate from a bottom trawl survey is likely to be an underestimate.

7.13 No new information on natural mortality and recruitment in this species had been submitted to CCAMLR. At last year's meeting it was noted that the only catches of *P. guntheri* that have been reported to CCAMLR as fine-scale data are from the South

Georgia area in 1987/88, an area where this species has not been found by research surveys (SC-CAMLR-IX, Annex 5, paragraph 143 and CCAMLR-IX, paragraph 13.24), Members viewed this with great concern as it introduces doubt as to the accuracy of fine-scale data reported to CCAMLR .

#### Management Advice

7.14 The very low level of fishing in 1989/90 and the absence of fishing in 1990/91 should have resulted in an increase of the biomass of this species. However, information crucial for assessing the state of *P. guntheri*, such as biomass estimates, estimates of natural mortality and recruitment values and fine-scale distribution of catches, are unknown for recent years. As the species is short-lived, the current state of the stock depends critically on the strength of the year classes which have recruited to the stock in the most recent years.

7.15 The Working Group therefore recommended that the present conservation measure should be retained until the information mentioned above becomes available which would allow a re-assessment of the stock to be made.

#### *Notothenia squamifrons* (Subarea 48.3)

7.16 A by-catch provision of 300 tonnes (Conservation Measure 13/VIII and 20/IX) and the prohibition of a directed fishery (Conservation Measure 22/IX) have been in force since 1989. The species was only taken in research vessel catches in 1990/91 and catches are unlikely to have exceeded a few tonnes.

7.17 No new information on this species has become available to the Working Group. The Working Group reiterated its statement from 1990 that despite the long catch history of this stock since 1971/72, very little information on length and no information on catch-at-age, recruitment or mortality estimates has been submitted to CCAMLR. The Working Group was therefore unable to assess the state of this stock.

#### Management Advice

7.18 In the absence of information which would allow an assessment of the stock, the conservation measures presently in force should be retained.

*Champscephalus gunnari* (Subarea 48.3)

7.19 Four conservation measures are currently in force with respect to *C. gunnari*. These comprise a mesh size limitation of 90 mm to apply from 1 November 1991 (Conservation Measure 19/IX), a limitation of the total catch in Subarea 48.3 for the 1990/91 season (Conservation Measure 20/IX), the prohibition of a directed fishery on the species between 1 April and 4 November 1991 (Conservation Measure 21/IX) and a catch reporting system in the 1990/91 season (Conservation Measure 25/IX).

Catches Reported

7.20 Data submitted to CCAMLR for 1990/91 were:

Member	Reported Catch (tonnes)	
Poland	41	Commercial
United Kingdom	3	Research
USSR	49	Research

7.21 Assessments performed at the 1990 meeting of WG-FSA indicated that there was a substantial stock of *C. gunnari* in Subarea 48.3, capable of supporting a TAC of between 44 000 and 64 000 tonnes (SC-CAMLR-IX, Annex 5, paragraph 139). The Scientific Committee suggested that the lower end of this range should be extended to reflect the uncertainty associated with the assessment and the possibility of high by-catch of *N. gibberifrons*.

Commercial Catch During 1990/91

7.22 The total reported catch of *C. gunnari* in Subarea 48.3 during 1990/91 was 93 tonnes, 52 tonnes of which was taken by two research surveys in the area. Commercial vessels targetting on *C. gunnari* in Subarea 48.3 during December and January failed to find any commercial concentrations and shifted their operations further south in search of krill. FV *Lepus* operated on the fishing grounds around South Georgia and Shag Rocks from

22 December 1990 to 15 January 1991, yielding a total catch of 30.5 tonnes\*. No commercial concentrations were found during this period, which has represented the peak fishing period in previous years. A report on the activities of the Polish commercial fishing vessel *Lepus* is provided in WG-FSA-91/36.

### Fishery Independent Surveys

7.23 The results of two bottom trawl surveys in Subarea 48.3 have been reported to the Working Group. A UK survey on *Falklands Protector* during January/February 1991 is reported in WG-FSA-91/14 and preliminary results from a USSR survey during April and May 1991 are reported in WG-FSA-91/23. The results of the *Falklands Protector* have been reported according to the recommendations in SC-CAMLR-IX, Annex 5, Appendix F. The only data available from the *Atlantida* survey were summary biomass estimates and preliminary discussion of the results (Table 2).

Table 2: Estimated biomass from the surveys in 1990/91.

Survey	Estimated Biomass (tonnes)	CV (%)
<i>Falklands Protector</i> WG-FSA-91/14 January/February 1991		
South Georgia	22 285	16
Shag Rocks	3 919	75
Total	26 204	16
<i>Atlantida</i> WG-FSA-91/23 April/May 1991		
South Georgia	172 920	44
Shag Rocks	19 224	23
Total	192 144	44

7.24 There is a considerable difference between these estimates. The magnitude of the *Atlantida* survey estimate (172 920 tonnes, CV of 44% at South Georgia and 19 224 tonnes, CV of 23% at Shag Rocks) appears to contradict evidence from the commercial fishery that no commercial concentrations were present in Subarea 48.3 from December to February. The degree to which the fish were aggregated and the distribution pattern during the *Atlantida* survey is currently not known. At the time of the *Atlantida* survey it is possible that the distribution of fish was significantly influenced by the onset of the spawning season.

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\* This catch of 30.5 tonnes is from the report of the survey undertaken by the FV *Lepus* whereas a total catch of 41 tonnes was reported in the STATLANT submission and by five-day reporting periods under Conservation Measure 25/IX.

7.25 The catches during the *Falklands Protector* survey (WG-FSA-91/14) were dominated by fish of lengths 12 to 19 cm, suggesting that the population at South Georgia was dominated by 1 year olds, possibly indicating a strong year class coming into the fishery in 1991/92. No size distribution from the *Atlantida* survey is currently available.

7.26 The *Akademik Knipovich* survey in 1989/90 produced a stock size estimate for South Georgia of 878 000 tonnes (SC-CAMLR-IX, Annex 5). The *Atlantida* survey in 1990/91 produced an estimate of 172 920 tonnes (WG-FSA-91/23), suggesting a drop in biomass of about 80%. The *Hill Cove* survey estimate for South Georgia in 1989/90 was 95 405 tonnes (WG-FSA-91/15) and the estimate from the *Falklands Protector* survey in 1990/91 was 22 285 tonnes (WG-FSA-91/14), suggesting a drop in biomass of about 77%. These direct comparisons should only be regarded as approximate indicators of change in stock size due to large CVs and possible differences in catchability between surveys. A summary of the results of all surveys is given in Table 3.

Table 3: Reported catches and summary of biomass estimates from surveys in Subarea 48.3.

Season	Reported Catch (tonnes)	Stock Assessment Surveys				Source
		South Georgia		Shag Rocks		
		Biomass	CV%	Biomass	CV%	
1984/85	14 144	15 821	101			SC-CAMLR-IV/BG/11
1984/85		17 232				SC-CAMLR-IX <sup>1</sup>
1985/86	11 107					
1986/87	71 151	151 293	95	62 867	84	Balguerias <i>et al.</i> , 1989 <sup>2</sup>
1986/87		50 414	18	10 023	55	SC-CAMLR-VI/BG/12
1986/87		51 017		4 229		SC-CAMLR-IX <sup>1</sup>
1986/87		47 312	-			Sosinski and Skora, 1987
1987/88	34 620	15 086	21	1447	78	SC-CAMLR-VII/BG/23
1987/88		15 716		509		SC-CAMLR-IX <sup>1</sup>
1987/88		17 913	-			Sosinski (unpubl.)
1988/89	21 356	21 069	50			WG-FSA-89/6
1988/89		22 328				SC-CAMLR-IX <sup>1</sup>
1988/89		31 686	45			Parkes (unpubl.) <sup>3</sup>
1989/90	8 027	95 405	63	279 000 <sup>4</sup>	83	SC-CAMLR-IX, Annex 5
1989/90		878 000	69	108 653	31	“
1989/90		887 000	31			“
1990/91	92	22 285	16	3 919	75	WG-FSA-91/14
1990/91		172 920	44	19 225	23	WG-FSA-91/23

<sup>1</sup> Calculated at WG-FSA-90 to take account of new sea bed areas in WG-FSA-90/8

<sup>2</sup> Semipelagic trawl used as a bottom trawl

<sup>3</sup> Data from *Professor Siedlecki* survey, February 1989 re-worked according to model 3 in WG-FSA-90/13 and using seabed areas in WG-FSA-90/8

7.27 Dr Gasiukov pointed out that another interpretation was possible if the trawl surveys carried out in seasons 1989/90 and 1990/91 are considered as independent measurements of the same biomass value. These observations indicate a large degree of uncertainty in estimates of the status of the stock using trawl surveys: in 1989/90 total biomass estimates for Subarea 48.3 were between 374 405 and 986 653 tonnes, and in 1990/91 between 26 204 and 192 144 tonnes.

### Population Dynamics

7.28 There are indications from both the commercial fishery and scientific surveys that there has been a significant reduction in stock size between 1989/90 and 1990/91. Simple cohort projections from 1989/90 to 1990/91 based on reported catches and normal levels of natural mortality do not account for the magnitude of this apparent reduction. There are a number of explanations which should be considered:

- (i) significant unreported fishing mortality during the latter part of 1989/90 and early 1990/91;
- (ii) significant increase in natural mortality over the assumed normal level (0.48 to 0.56);
- (iii) significant emigration of fish from Subarea 48.3 to other areas; and
- (iv) bottom trawl surveys of the type conducted in recent years may not accurately reflect the abundance of this species.

7.29 With regard to (i), there is no evidence of significant unreported fishing mortality of *C. gunnari* in the period 1989/90 to 1990/91.

7.30 With regard to (ii), there is evidence from various sources that there were some peculiarities in Subarea 48.3 during the 1990/91 season, which could lead to an increase in natural mortality above the usual level. Evidence from the *Falklands Protector* survey reported in WG-FSA-91/29 indicates that krill, the preferred prey of *C. gunnari*, was in short supply during the survey and the fish were relying on food with a lower calorific value (e.g. *Themisto gaudichaudii*). In addition other predators which normally rely on krill, such as black-browed albatross, macaroni penguins and fur seals, have shown poor breeding success at South Georgia in 1990/91. Other predators which do not rely on krill (e.g. grey-headed

albatross) have bred successfully. If this situation were characteristic of the first half of 1990/91 it is possible that *C. gunnari* were suffering from a food shortage and predators (e.g. fur seals) normally targetting krill shifted their attention to finfish, particularly *C. gunnari*. The commercial catch of krill in Subarea 48.3 during 1990/91 was approximately 40 000 tonnes which is about 50% of the 1989/90 level.

7.31 WG-FSA-91/7 reports evidence from the *Falklands Protector* survey that the reproductive performance of adult *C. gunnari* in the period leading up to spawning was poor, possibly as a result of poor feeding conditions. 60% of the fish sampled during the *Atlantida* survey (April/May) were in stage III according to the same scale as used on the *Falklands Protector* survey. At this time of year a greater proportion of fish might be expected to be at maturity state IV or V if the maturation process were progressing normally.

7.32 It is possible that a large-scale emigration of *C. gunnari* from Subarea 48.3 has occurred, although movements of this species between shelf areas were thought to be limited (e.g. WG-FSA-90/10). WG-FSA-91/22 presents an analysis of the genetic variability of *C. gunnari* in Antarctic waters during 1990/91 and reports that, for instance, insufficient genetic difference between Subareas 48.3 (South Georgia and Shag Rocks) and 48.2 (South Orkney Islands) was detected to refute the possibility that fish have moved between these two areas. The precise nature of such a migration is unknown, but it could be in response to changes in food availability, which might be the result of changes in oceanographic conditions. WG-FSA-90/30 presents a preliminary investigation of the relationship between sea surface temperature and seasonal changes in abundance of *C. gunnari* at South Georgia, but no clear relationship was detected.

7.33 Changes in genetic variability between 1989/90 and 1990/91 described in WG-FSA-91/22 are thought to be indicative of both abrupt changes in population size and increased mobility of individuals.

7.34 Suggestions were made in the Working Group that significant numbers of *C. gunnari* from Subarea 48.3 could have migrated as far as the South Orkney Islands in Subarea 48.2 (WG-FSA-91/22). If this were the case then adult fish absent from the population at South Georgia during the *Falklands Protector* survey might be expected in that area.

7.35 The results of a bottom trawl survey around the South Orkneys during January/February 1991 are presented in WG-FSA-91/33. The catches of *C. gunnari* during this survey were larger than expected and the standing stock was estimated to be in the region of 10 000 to 40 000 tonnes, depending upon the method of stratification. The length

distribution of the catch during this survey indicates a predominance of larger fish (length 35 to 48 cm), although this may be the result of few samples being taken in shallow water, where the proportion of smaller fish is generally greater.

7.36 With regard to (iv), the Working Group agreed that changes in biomass estimates from only a few trawl surveys do not necessarily indicate any substantial change in stock size because the estimates themselves are subject to considerable uncertainty. However, some Members observed that, taken in conjunction with the apparent absence of fishable concentrations at the usual peak of the fishing season, the poor condition of specimens and the low abundance of krill, the decline in survey biomass estimates is suggestive of a real change in the abundance of the stock.

#### Assessments Presented at the Meeting

7.37 Two assessments of *C. gunnari* in Subarea 48.3 have been presented. WG-FSA-91/15 presents a VPA tuned to bottom trawl survey abundance indices between 1986/87 and 1990/91 (Laurec-Shepherd method), which estimates population size in July 1990 (start of 1990/91) to be between 32 000 and 41 500 tonnes. Catch levels for 1991/92, based on  $F_{0.1}$  are in the region of 8 000 to 14 000 tonnes. This paper suggests that a decline in recruitment of 1 year olds and spawning stock abundance has occurred over recent seasons. WG-FSA-91/27 presents a VPA tuned to both standardised catch/effort indices by age group between 1982/83 and 1989/90 and survey abundance indices between 1984/85 and 1990/91 (adaptive method). This estimates population size at the start of 1990/91 to be 184 000 tonnes and advises a TAC of 59 400 tonnes based on  $F_{0.1}$ .

7.38 The two assessments give very different results (Figure 2). This is mainly because of the different indices and standardisation used to tune the VPAs, but also involves the VPA fitting procedures and minor variations of input data for catch-at-age and mean weights-at-age.



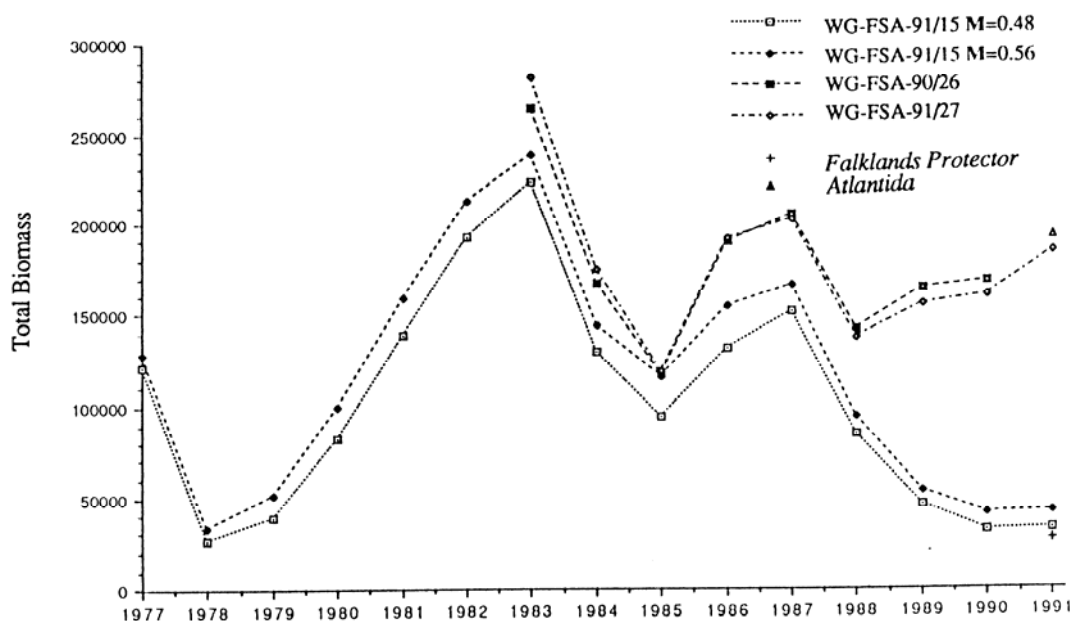


Figure 2: Comparison of total biomass from VPAs presented to the Working Group in 1990 and 1991.

7.39 The catch-at-age data used in the two assessments were different in some years due to differences in the application of age/length keys and length distributions. The catch-at-age in WG-FSA-91/15 was taken from previous analyses performed at the Working Group (WG-FSA-90/5), but due to the absence of data from the commercial fishery, information for years 1989/90 and 1990/91 was derived from surveys. The catch-at-age in WG-FSA-91/27 was the same as in WG-FSA-91/15 for seasons 1986/87 to 1988/89, but differed in other years.

7.40 Dr Gasiukov pointed out that this difference had been discussed at the Working Group's meeting in 1989. It was noted that the catch-at-age structure used in WG-FSA-91/15, determined over a number of years and based solely on two age/length keys leads to biased assessments of age-specific yield (SC-CAMLR-VIII).

7.41 Although it was not possible to resolve differences between the two catch-at-age series, this was not the major source of variation between the results of the two analyses.

7.42 The survey indices used in WG-FSA-91/27 for 1989/90 and 1990/91 combined the biomass estimates from both South Georgia and Shag Rocks, but used estimates for South Georgia only from 1984/85 and 1988/89, leading to an inconsistent series of abundance indices. In addition, the inclusion of a semipelagic trawl in the survey from 1986/87, with the possible difference in catchability, adds further inconsistency to the series. The 1991 result from the *Falklands Protector* survey was not included.

7.43 Dr Gasiukov pointed out that WG-FSA-91/15 only employed data from trawl surveys in the South Georgia area which does not reflect the status of the *C. gunnari* stock in its entire distribution area. Information has not been taken into account from Shag Rocks where a significant proportion of the stock may be located. Moreover, this part of the stock may vary disproportionately over different years. For example, this part comprised 37% in 1989/90 and 15% in 1990/91. Therefore, the abundance indices in WG-FSA-91/15 are not representative of the status of the *C. gunnari* stock. Results from trawl surveys carried out by RV *Akademik Knipovich* (1989/90) and *Atlantida* (1990/91) were not included.

7.44 Dr Gasiukov further noted that the standardisation of trawl survey-based abundance indices used to tune the VPA in WG-FSA-91/27 used the adaptive algorithm and presupposes the calculation of residuals using the values standardised according to the month in which the trawl survey was carried out.

7.45 The standardising of indices using equation (3) of WG-FSA-91/15 is suspect because values of different dimensions were used for  $N_a$  and  $C_{ai}$ .

$$N_a = N_{at} e^{[m(t-1)/12]} + \sum_{i=1}^{t-1} C_{ai} e^{[m(t-i-1)/12]}$$

where  $a$  = age group  
 $i$  = sequential month number (July = month 1)  
 $t$  = month at the start of the survey  
 $M$  = natural mortality rate  
 $N_a$  = standardised index of abundance (number of fish-at-age  $a$  on 1 July)  
 $N_{at}$  = index of abundance at the time of survey  
 $C_{ai}$  = catch by age group per month.

Thus, the abundance indices presented in WG-FSA-91/15 are biased and do not reflect the abundance dynamics of *C. gunnari* in Subarea 48.3.

7.46 In the work presented in WG-FSA-91/15 a selected series of surveys using bottom trawls at South Georgia were used for tuning the VPA. Surveys were selected on the basis that they represented a consistent series of abundance indices which were representative of changes in the size of the population of *C. gunnari* in Subarea 48.3. WG-FSA-91/16 presents the details of the bottom trawls used during these surveys and suggests that, with the possible exception of the HC-120 trawl used during the *Hill Cove* survey of 1989/90 (WG-FSA-90/11 Rev. 1) the catchability of the trawls was consistent. There was insufficient

information available for the trawls used during the *Akademik Knipovich* and *Anchar* surveys of 1989/90 (WG-FSA-90/29 and 30) to allow the same comparison. Indices from Shag Rocks were not included due to the absence of data for 1988/89 and the higher degree of uncertainty associated with those available for other years (see Table 3).

7.47 The survey indices used were weighted by the inverse of the variance of the stratified mean haul, leading to a reduction of the influence of estimates with a high degree of uncertainty. This would tend to automatically down-weight high survey estimates with large variances. As a result the 1989/90 abundance index from the *Hill Cove* survey has very little influence on the tuning of the VPA abundance estimate. This is, however, a real result which should not be ignored, although some weighting related to the precision of the estimates is desirable. A better approach might be to weight the survey estimates by the inverse of the square of the CV.

7.48 Dr Gasiukov stated that the weighting factors presented in WG-FSA-91/15 fundamentally lead to an underestimation of the size of the *C. gunnari* stock in years of high abundance and biomass which was especially so for the biomass estimate in 1989/90 and to a large extent influence the stock assessment for 1990/91.

7.49 In WG-FSA-91/27 an attempt was made to tune the VPA using both CPUE and survey indices. The concept of including all of the available information in the model has merit. In addition, the method takes account of the precision of the indices by weighting the relative abundance indices. However, a comparison of the results in WG-FSA-91/27 with those presented in WG-FSA-91/26, which was tuned to CPUE indices only, suggests that the inclusion of the survey indices in the assessment model had very little influence on the VPA. It appears that the application of the adaptive method in WG-FSA-91/27 placed undue weight on the CPUE indices.

7.50 Dr Gasiukov pointed out the fundamentally divergent approaches to *C. gunnari* stock assessment applied in WG-FSA-91/15 and 27. The first of these documents only uses limited information from selected trawl surveys while the second employs an approach based on the integrated use of observation data obtained from various sources and including CPUE values over a number of years from fishing vessels as well as trawl survey data for the seasons 1984/85 to 1990/91. Also, if several surveys were undertaken in certain years (e.g. in 1989/90) this is also taken into consideration in the calculation.

7.51 In WG-FSA-91/27 the total effort data from the commercial fishery was used with the catch-at-age matrix to CPUE derive indices for six age classes over eight years, a total

of 48 indices. A total of seven trawl survey indices were used from the period 1985 to 1991. The relative weighting of the alternative CPUE indices and trawl survey results was based on the values of the CV. The trawl surveys were assigned an average CV of 0.4, while the CPUE data in WG-FSA-90/26 gave a mean CV of 0.319. The weighting factors therefore were 1 for CPUE indices and 0.89 for trawl survey indices.

7.52 There is a problem with the application of the adaptive approach in WG-FSA-91/27 concerning the minimisation of the sum of squares. The squared deviations of the 48 indices of CPUE using a weighting factor of 1 have been combined with seven trawl survey indices with a weighting factor of 0.89. The CPUE series therefore dominates the analysis and not surprisingly the results in WG-FSA-91/27 closely follow those of WG-FSA-90/26 (Figure 2).

#### Assessments Made at the Working Group

7.53 A proposal to run a VPA, using Laurec-Shepherd tuning, with both the survey indices from WG-FSA-91/15 and the standardised CPUE indices from WG-FSA-91/27 was investigated. Unfortunately this could not be done with the program (MAFF VPA program version 2.1) in its current form due to: (i) the lack of a CPUE index for 1990/91 (the most recent year); and (ii) the inability of the program to accept separate series of weights for the separate regressions of the two indices. The VPA was re-worked by the Working Group in an attempt to see what influence the different tuning methods had on the results and allow the recommendation of appropriate management advice.

7.54 Two separate VPA runs were made, the first tuned to survey indices presented in WG-FSA-91/15, the second tuned to CPUE indices presented in WG-FSA-90/26. Details of the input data are presented in Appendix F.

7.55 Analysing these input data Dr Gasiukov referred to a number of studies undertaken in recent years (Zh. Frolkina and R. Dorovskikh, 1989; Zh. Frolkina and R. Dorovskikh, 1990; P. Sparre, 1990; P. Gasiukov and R. Dorovskikh, 1991) which support a value of 0.56 for the natural mortality coefficient. Calculations based on  $M = 0.48$  lead to a lower estimate of the *C. gunnari* biomass and also to a 20% decrease in  $F_{0.1}$ . This in turn produces a significantly reduced value of TAC.

7.56 Figure 3 illustrates the total estimated biomass of age 2+ from these two runs. Results from run 1 show a similar pattern to the assessment in WG-FSA-91/15 and results from run 2

show a similar pattern to the assessment in WG-FSA-91/27. There is a difference between the two runs in the most recent years.

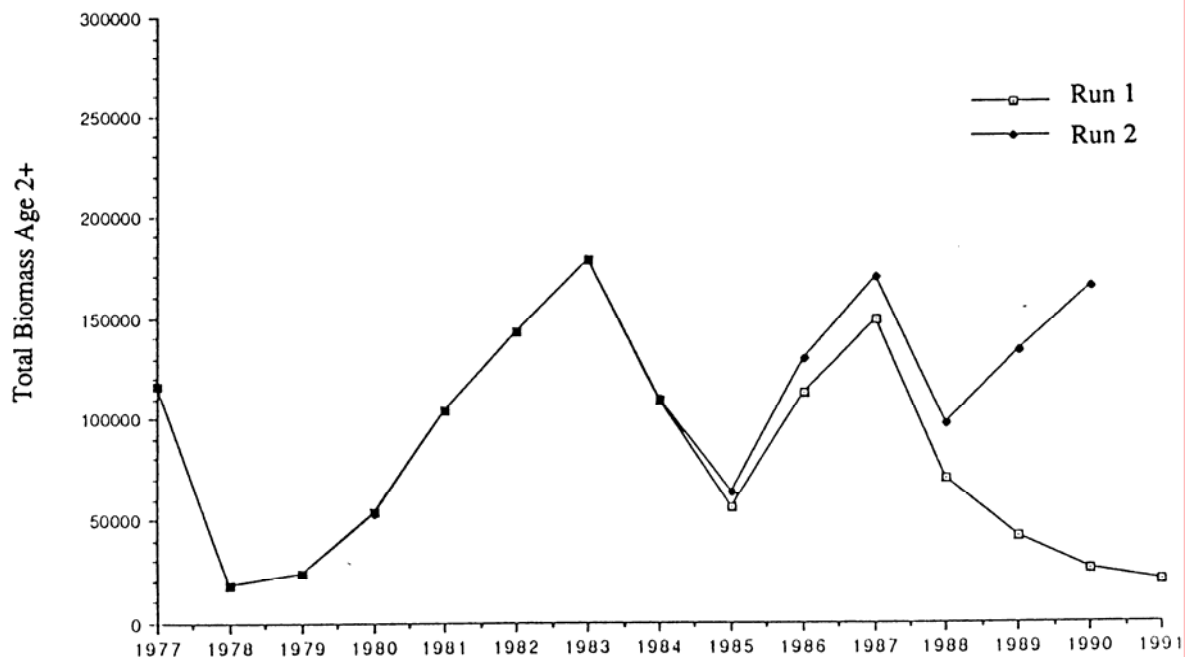


Figure 3: Biomass of *C. gunnari* for both assessment runs: run 1 tuned to survey indices, and run 2 tuned to CPUE indices.

7.57 Y/R analyses presented in WG-FSA-91/15 and 27 provide estimates of  $F_{0.1}$  summarised in Table 4.

Table 4: Values of  $F_{0.1}$  based on Y/R analyses.

Selectivity	$M = 0.48$	$M = 0.56$	Source
Knife edge:			
$t_c = 1$ year	0.27	0.32	WG-FSA-91/15
$t_c = 2$ years	0.39	0.44	"
$t_c = 3$ years	0.54	0.64	"
$t_c = 4$ years	0.74	0.84	"
Partial recruitment:			
80 mm mesh (WG-FSA-90/27)	0.44	0.51	WG-FSA-91/15
90 mm mesh (WG-FSA-91/27)	-	0.65	WG-FSA-91/27

7.58 In accordance with Conservation Measure 19/IX, the minimum mesh size permitted in the fishery targeting *C. gunnari* will increase from 80 mm to 90 mm on 1 November 1991. WG-FSA-91/27 presents a theoretical assessment of selectivity by a 90 mm mesh assuming

selectivity is described by the logistic curve, the correct estimation of selectivity by the 80 mm mesh, and growth according to the von Bertalanffy growth equation. Estimated coefficients of partial recruitment are given in Table 5:

Table 5: Change in coefficients of partial recruitment estimated to apply to the change in mesh size.

Age Group:	1	2	3	4	5	6
Partial recruitment (80 mm)	0.04	0.42	1.0	1.0	1.0	1.0
Partial recruitment (90 mm)	0.01	0.15	0.77	0.98	1.0	1.0

7.59 Some Members felt that high catches of 2 year olds taken by the 80 mm mesh in the past (e.g. SC-CAMLR-VII, Annex 5, Table 1), however, suggest that the coefficient of partial recruitment for that age may be underestimated, particularly at high catch rates (Slosarczyk *et al.*, 1989). Assumption that future exploitation will not take a significant proportion of 2 year olds, even with the 90 mm mesh, is unrealistic. A more conservative approach would be to consider  $F_{0.1}$  for knife edge selection at a  $t_c$  of 2 years.

7.60 Dr Gasiukov felt that using  $t_c = 2$  in the knife-edge selection is not consistent with Conservation Measure 19/IX which sets a 90 mm mesh size from 1 November 1991. Calculations in WG-FSA-91/27 show that the partial recruitment coefficient for the age group 2 would decrease three-times and be equal to 0.15 of the value for fully exploited age groups.

7.61 Therefore using  $F_{0.1}$  at  $t_c = 2$  would decrease the coefficient  $F_{0.1}$  two-times; this would not be the optimal fishing regime.

## Projections

7.62 Population projections were prepared assuming  $M = 0.48$ ,  $t_c = 2$  years and the catch in 1991/92 to be equivalent to exploitation at the  $F_{0.1}$  level (0.39). A mean value of recruitment was assumed: mean over the period 1985/86 to 1989/90 for projection 1 (from run 1) and mean over the period 1985/86 to 1988/89 for projection 2 (from run 2). The algorithms used for the cohort projections are as shown in WG-FSA-91/15.

7.63 The results of the projections are set out in Table 6. VPA run 1 is projected forwards from July 1990 (start of 1990/91) and VPA run 2 is projected forwards from July 1989 (start of 1989/90). The latter projection involves one more season and therefore includes a higher degree of uncertainty.

Table 6: Results of projections using cohort analysis (numbers x 1 000). Biomass values assume mean weights-at-age in WG-FSA-91/15.

Projection 1 from VPA run 1:							
Age Class	Population Numbers	Catch-at-Age 1989/90	Population Numbers July 1990	Catch-At-Age 1990/91	Population Numbers July 1991	Catch ( $F_{0.1}$ ) (tonnes) 1991/92	Population Numbers July 1992
1			289 863	2	289 863	0	289 863
2			47 076	215	179 361	4 308	179 362
3			29 962	242	28 961	1 416	75 144
4			31 081	86	18 350	1 508	12 133
5			1 036	4	19 165	2 335	7 688
6			518	2	638	106	8 029
Total Biomass (tonnes)			26 938		41 834	<u>9 672</u>	47 291

Projection 2 from VPA run 2:							
Age Class	Population Numbers	Catch-at-Age 1989/90	Population Numbers July 1990	Catch-At-Age 1990/91	Population Numbers July 1991	Catch ( $F_{0.1}$ ) (tonnes) 1991/92	Population Numbers July 1992
1	791 488	240	791 488	2	791 488	0	791 488
2	192 860	6 195	489 571	215	489 758	11 762	489 760
3	622 567	31 920	114 465	242	302 769	14 805	205 185
4	39 571	1 967	360 125	86	70 639	5 805	126 846
5	2 842	96	22 939	4	222 772	27 137	29 594
6	30	1	1 683	2	14 191	2 361	93 331
Total Biomass (tonnes)	156 626		195 833		236 779	<u>61 870</u>	200 428

7.64 Exploitation at  $F_{0.1}$  produces catches in the 1991/92 season of 9 672 tonnes in projection 1 and 61 870 tonnes in projection 2.

#### Interpretation of the Assessments

7.65 Figure 4 illustrates the pattern of recruitment over time for the two VPA runs. The pattern for both runs shows considerable variation. The use of the mean over the period 1985/86 to 1988/89 for the projection of run 2 may over-estimate future recruitment given the very large value in 1987/88.

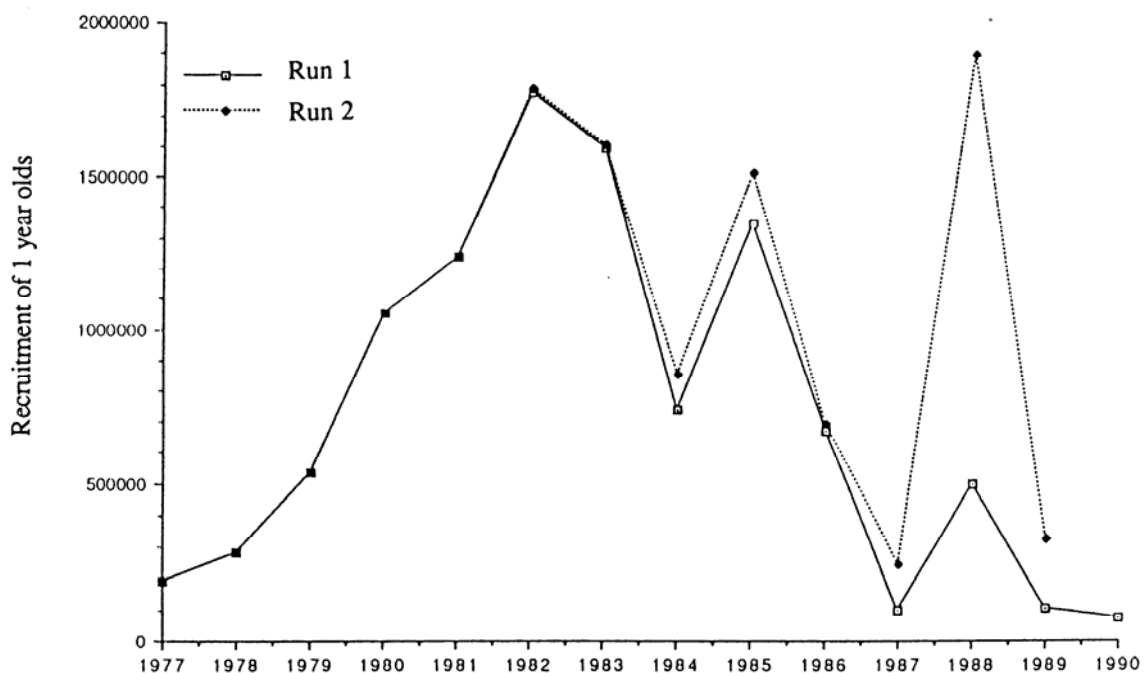


Figure 4: Recruitment (age 1) of *C. gunnari* for both assessment runs.

7.66 The projections in Table 6 depend critically on the size of the recruiting age classes. Observations from the 1991 trawl survey (UK) suggest that the 1 year old age class was abundant in 1991; these 1 year old fish will begin to recruit into the fishery as 2 year olds next year.

7.67 The size of the 1 year old age class in 1992 is not critical to this assessment as the fishery in 1991/92 will not rely on these smaller fish. Because of the importance of recruitment in the projection model, prediction of the population size more than one year ahead becomes unreliable. This shows the value of trawl surveys for estimating the abundance of pre-recruits in the year preceding catches for which a TAC is set. In the absence of any independent abundance estimate, the mean recruitment based on the VPA results could be used. This is not a conservative approach, however, as it assumes no trend in recruitment has occurred, and there is no clear relationship between stock size and recruitment.

7.68 Dr Gasiukov drew to the attention of Working Group members, discrepancies between estimates of recruitment in run 1 and the results of trawl survey observations presented in Table 4 of Appendix F.



7.69 While a tendency towards a decrease in abundance of age group 1 may be evident from these particular VPA results, then trawl survey data indicate the converse; recruitment in 1988/89 is from 10- to 20-times higher than in seasons 1986/87 and 1987/88; and in 1990/91 is 10-times greater than in seasons 1986/87 and 1987/88.

7.70 Dr Gasiukov felt that this is the result of an inadequately tuned VPA which in the terminal year uses only the results of a UK trawl survey and disregards survey results from 1988/89 and the results of trawl surveys by RV *Atlantida* in 1990/91.

7.71 The results of the trawl surveys from 1987 to 1991 (Table 4 of Appendix F) can be used to look at the relative frequency of age classes and compare them to the pattern of recruitment seen in the VPA results. In the 1989 survey, the 1 year old cohort was abundant, whereas the VPA suggests a large 2 year old cohort. This anomaly is of major concern for this assessment.

7.72 There are two important factors to consider when interpreting the results of the VPA:

- (i) the catch of 2 year old fish in 1989 by the commercial fishery could indicate that a very abundant year class entered the fishery or alternatively, it could suggest that the fishery targetted younger fish or the older age classes were not abundant; and
- (ii) there is uncertainty whether catches in 1989 were in fact strongly dominated by the 2 year old cohort. The age distribution of the catch for 1989 used in the VPA was determined by application of an age/length key from Polish data. The use of an age/length key from Soviet data gives a different distribution of age classes in the catch.

7.73 Dr Gasiukov stated that the suggestion that the predominance of two year old fish in catches in 1989 is the result of a very abundant year-class is the more plausible. This fact is substantiated by the size structure of catches from the RV *Hill Cove* trawl survey in 1990, presented in Figure 2 of WG-FSA-90/26.

7.74 The uncertainties concerning the catch-at-age data input to the VPA and the effect this has on the assessment make the current status of the *C. gunnari* stock unknown. The alternative VPA models presented show quite different trends in the most recent years. However, in terms of recruitment, the trawl survey data which are based on a random design should more accurately reflect the true pattern of year class strength in the population.

7.75 The variability in year class strength of *C. gunnari* is such that large fluctuations in stock size are likely. These year to year changes in biomass can be minimised by retention of more age classes in the population by fishing at a lower exploitation rate. Although this may reduce the yield from the stock over a number of years it will increase the stability of the population and the fishery by reducing dependence on the recruiting year class.

7.76 The apparent abundance of the 1 year old cohort in 1991 suggests that the fishery could operate more successfully in 1992 on 2 year old fish. However, the large number of fish projected from the VPA in previous assessments (particularly from the cohort spawned in 1988) cannot be relied upon to sustain the fishery. In 1990/91, these fish were not located in abundance by the fishery. Although the *Atlantida* survey detected fish in abundance during April/May 1991, no length or age composition data were available from this survey.

7.77 Dr Gasiukov felt that uncertainty in estimates is to a large extent determined by the fact that the trawl survey data used do not adequately reflect the status of the *C. gunnari* stock: this can be seen in Figure 5. This leads to a significant underestimation of the stock in WG-FSA-91/15 and run 1. It is worth noting the discrepancies existing between both the above calculations and stock assessment results obtained by the Working Group in 1990 and independent biomass estimates obtained by three research vessels in 1990. There is good agreement between results of stock assessment in 1990 and VPA results in WG-FSA-91/27 and run 2. This leads one to conclude that there is a greater degree of robustness in the latest estimates. The correlation coefficient for the relationship between mean weighted fishing mortality coefficients of the major age groups and fishing effort in these estimates equals 0.72 (WG-FSA-90/26) (Figure 6). The above is the rationale for including in management advice the TAC given in WG-FSA-91/27 and run 2.

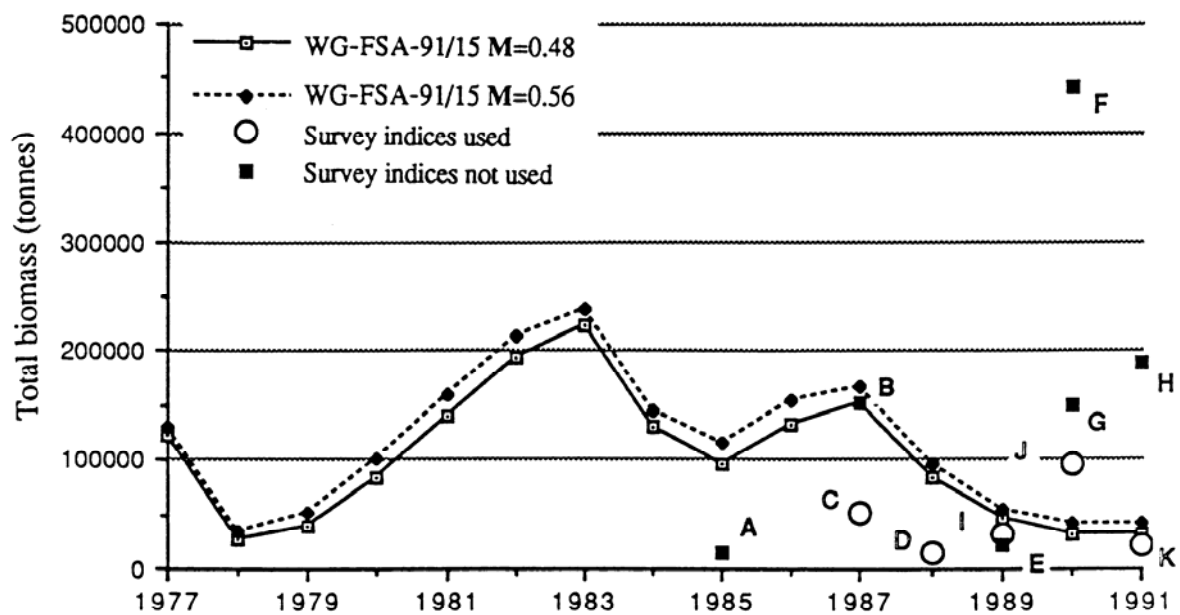


Figure 5: WG-FSA-91/15. Total biomass from VPA and from surveys used in tuning.

Note: Open circles represent survey biomass estimates, not standardised indices used in run 1.

A - Kock *et al.*, 1985

B - Balguerías *et al.*, 1989

C - SC-CAMLR-VI/BG/12

D - SC-CAMLR-VII/2

E - WG-FSA-89/6

F - SC-CAMLR-IX

G - SC-CAMLR-IX

H - WG-FSA-91/23

I - Unpublished

J - WG-FSA-90/11

K - WG-FSA-91/14

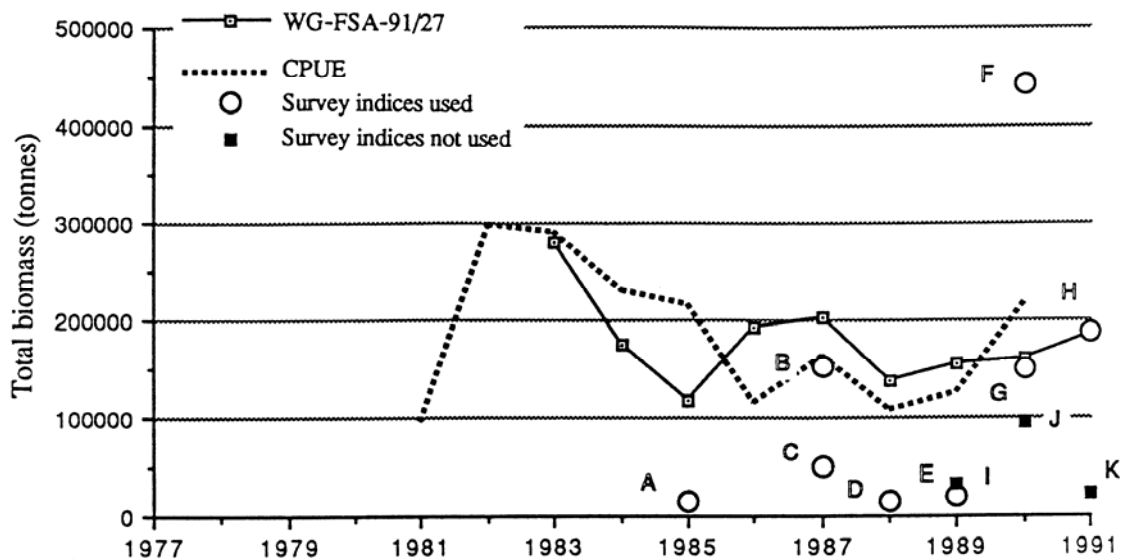


Figure 6: WG-FSA-91/27. Total biomass from VPA. CPUE and survey biomass used in tuning.

7.78 Some Members expressed the opinion that although there are uncertainties associated with results from all trawl surveys, they do provide the most reliable basis for assessing the state of the stocks.

#### Management Advice

7.79 Assessments presented to the Working Group and performed during the meeting provide a wide range of possible catch levels in 1991/92 based on the  $F_{0.1}$  management strategy (8 400 to 61 900 tonnes).

7.80 Dr Gasiukov suggested that the highest value could form the basis for a TAC.

7.81 Other Members felt that a much more conservative level would be appropriate considering the uncertainties associated with the current population size, year class strength, and future recruitment.

7.82 The by-catch of other species in the pelagic trawl fishery may have implications for the TAC of *C. gunnari* in 1991/92. This problem was identified in paragraph 3.42 of SC-CAMLR-IX with regard to the by-catch of *N. gibberifrons* and discussed in this report (paragraph 8.10).

7.83 No new information was presented to the Working Group concerning mesh selectivity of *C. gunnari*. The Working Group had no reason to suggest changes to the mesh regulation size of 90 mm in Conservation Measure 19/IX.

7.84 Assessment of the implications of a re-introduction of commercial bottom trawling in Subarea 48.3 on the by-catch of demersal fish species is given in paragraphs 7.189 to 7.197. The Working Group endorsed the ban on the use of bottom trawls in the directed fishery for *C. gunnari* in Subarea 48.3 (Conservation Measure 20/IX).

7.85 The Working Group supported the continuation of Conservation Measure 21/IX imposing a closed season for *C. gunnari* in Subarea 48.3 between 1 April until the end of the Commission meeting in 1992.

*Dissostichus eleginoides* (Subarea 48.3)

7.86 In accordance with Conservation Measure 24/IX, the total catch of *D. eleginoides* for the period 2 November 1990 to the end of the Commission meeting in 1991 was limited to 2 500 tonnes. Conservation Measures 25/IX and 26/IX, relating to the reporting of catch, effort and biological data, were also in force.

7.87 Data from five-day reporting periods were submitted. No haul-by-haul data (Conservation Measure 26/IX) have been submitted for the 1990/91 season. Length frequency data (Conservation Measure 26/IX) have been submitted for some months but not yet for the entire period.

7.88 Catch levels of *D. eleginoides* in Subarea 48.3 since 1988 are summarised in Table 1. The reported catch taken in 1990/91 consisted of 1 440 tonnes caught before the meeting of the Commission and 2 394 tonnes caught since 2 November 1990. All catches reported in 1990/91 were taken by longlining.

7.89 Two assessments by Members were presented to the Working Group. The assessment in WG-FSA-91/20 is based on estimates of young fish obtained from two bottom trawl research surveys, projected forward to allow estimation of the exploitable biomass. The assessment presented in WG-FSA-91/24 is based on a generalised cohort analysis of size composition in the catches.

7.90 It was pointed out that the projected biomass figures presented in WG-FSA-91/20 were likely to be over-estimates since only natural mortality was considered in the projection procedure. These were essentially estimates of future biomass and only indicated current biomass under the assumption that the observed levels of young fish could be considered as average.

7.91 Some Members expressed concern that not all fish in the water column are sampled by a bottom trawl. It was pointed out that this effect should be minimised since all trawls were made during the day when fish are less dispersed in the water column. Results did, however, indicate that because of the depth distribution of individuals (small specimens predominate in shallow water and the greatest number of large fish are found in deeper waters), bottom trawl surveys are likely to underestimate the total standing stock but that young fish are likely to be relatively well represented and may therefore give some indication of future recruitment to the fishery.

7.92 It was suggested that there may be migration or mixing of the species along the Patagonian slope toward the Antarctic Peninsula and South Georgia. If this was the case, the surveys would only be sampling young fish of part of the total population. There is currently no information to suggest whether or not there is migration. The Working Group felt that further work on this matter would be useful.

7.93 WG-FSA 91/20 also presented results of an attempt at estimating natural mortality between age-group 2 in 1989/90 and age group 3 in 1990/91. The estimate was found to be unrealistically large and although many possible explanations could be given there was no further information to suggest which was the most likely.

7.94 Drs Gasiukov and Shust felt that it was important to highlight the impossibly high estimate of natural mortality derived by comparison of the abundance estimates from the two surveys. This unsuccessful attempt demonstrates that the input data used have a very high degree of uncertainty (CV of biomass estimates of *D. eleginoides* during the 1990/91 survey was 97%: WG-FSA-91/14). As the same input data from trawl surveys are used for further calculations of TAC. This results in the same level of uncertainty. It becomes particularly clear when results obtained from two years are compared (see Table 8).

7.95 Other Members were of the opinion that, whereas the estimate of natural mortality based on direct comparison of data from two surveys would be very imprecise, the projections use the data from one survey at a time with independent estimates of natural mortality from previous analyses by the Working Group (SC-CAMLR-IX, Annex 5, paragraph 157). These projections were therefore considered to be valid.

7.96 It was pointed out that the CVs of the survey estimates were very high, particularly in the most recent year (WG-FSA-91/14). There is also a large difference between estimates for 1990 and 1991, which is due to a single large catch of large fish obtained in the 1991 survey. This is discussed further in WG-FSA-91/20. Estimated biomass from bottom trawl surveys around Shag Rocks since the beginning of the fishery (WG-FSA-91/14) which consisted primarily of immature fish is between 400 and 20 000 tonnes, indicating a very large range. Adult fish are mostly found in the water deeper than 500 m, beyond the range of the trawl surveys.

7.97 Attention was drawn to the fact that the highest catch level of 8 311 tonnes was very close to and even greater than some of the biomass estimates. It was recognised that the estimates from surveys could not be considered as estimates of total exploitable biomass for the reasons outlined above (paragraph 7.91).

7.98 Members felt that it was preferable to use a dynamic rather than an equilibrium approach in assessing the status of this stock. However, not enough information was available to enable such an approach in this case.

7.99 With respect to the assessment presented in WG-FSA-91/24 the following comments were made. It was pointed out that the analysis was not tuned to independent data but run under the assumption that the fishing mortality in the most recent year (1990/91) was equal to the long-term average fishing mortality. This choice is relatively arbitrary, but was made in the absence of any information on the magnitude of terminal **F** values. The Working Group also recognised that it would be inappropriate to tune the analysis to survey estimates because of the problems outlined above (paragraphs 7.91 and 7.96).

7.100 The author indicated that the iterative procedure always converged to the same value, irrespective of starting values and that there was good agreement between values of fishing mortality for 1988/89 and 1990/91, years in which total catch levels were very similar. This was interpreted as indicating satisfactory tuning.

7.101 Other Members felt that the tuning was driven by the assumption about terminal **F** values and that agreement between catch levels and **F** values in 1988/89 and 1990/91 could only be expected if actual population levels were also similar.

7.102 It was noted that a set of age determinations was used to obtain the growth curve that was used to divide the catches at size into nominal age classes and that variability in growth rates between years could affect this 'slicing' of length frequency distributions. The Working Group agreed that more age/length data for this species were needed and that a larger number of individuals (than the 218 used in this analysis) should be sampled for age determination.

7.103 The author pointed out that although a set of age determinations was used the fitted growth curve gives a good approximation to the data (WG-FSA-91/24, Figure 2). A functional regression was used to obtain the growth curve and a jack-knife procedure was used to estimate the SD of the parameter estimates. The sensitivity of results from the generalised cohort analysis to differences in the growth function were also investigated.

7.104 There was a large difference between the weight and age of the largest fish caught in the longline fishery used in WG-FSA-91/20 and 24. WG-FSA-91/24 uses age determinations which identify fish of weight 23 kg as about 23 years of age.

7.105 WG-FSA-91/20 uses von Bertalanffy growth parameters and a length-weight relationship. These parameters imply that fish of weight 23 kg are about 18 years of age. Dr Gasiukov stated that these parameters also imply that a fish of length 170 cm and of weight 56 kg would be 50 years old and that this seems unlikely to him.

7.106 These disparities in size-at-age suggest that if the age determinations are reliable, there is still some uncertainty about estimates of growth parameters.

7.107 The Working Group also felt that size selectivity of longline gear may affect estimates of demographic parameters. Paper WG-FSA-91/11 indicated that the type and size of hook has a strong effect on the sizes of fish caught. It was suggested that experiments using straight and circular hooks should be done to investigate this matter further.

7.108 A description of the fishery in the most recent year (1990/91) was presented in WG-FSA-91/34. The document included graphs of catch-per unit-effort (CPUE) for the period October 1989 to August 1991. Data for the most recent period were from the five-day reports, whereas data for the previous years were from STATLANT B data.

7.109 The CPUE series in WG-FSA-91/34 showed a sharp decline in 1991 and the Working Group felt that this warranted further investigation. During the meeting, the STATLANT B data for 1991 became available, which enabled the Working Group to construct a CPUE index based on number of hooks rather than number of ship days as used in WG-FSA-91/34. Figure 7 shows that, over the period considered (October 1989 to June 1991), there have not been any large changes in catch-per-unit-effort. The seasonal pattern in 1990/91 is similar to that in 1989/90 but seems to be at a slightly lower level.

7.110 It was noted that the CPUE series suggests that it is unlikely that the population size is increasing. This is contrary to the results from the generalised cohort analysis (WG-FSA-91/24) which indicates an increase in population size.

7.111 The Working Group drew attention to the fact that no change in the CPUE does not necessarily reflect no change in population abundance. A small decrease in CPUE may be associated with a relatively large decrease in population size when CPUE is proportional to a power function of population size.



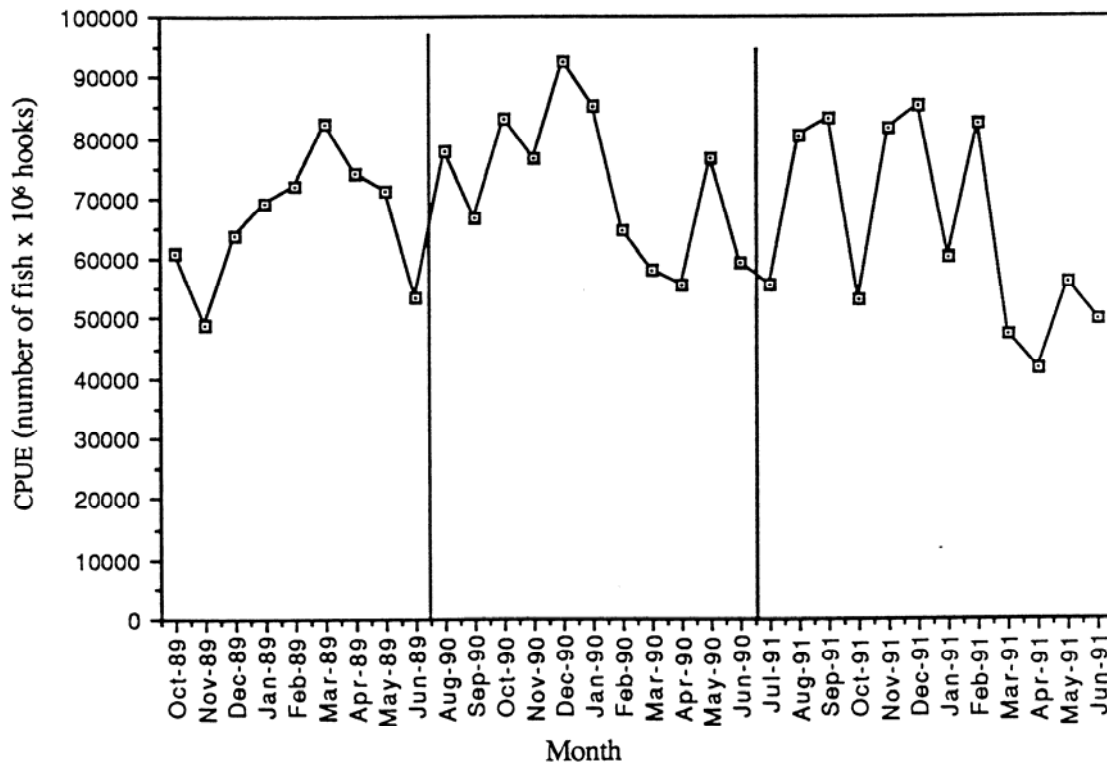


Figure 7: CPUE (numbers per million hooks) for *D. eleginoides* calculated from STATLANT B data assuming a mean weight of 10.82 kg/fish, a weight which was derived from the five-day reporting period data.

7.112 It was also pointed out that the five-day reporting data seems to suggest that the fleet moves from one fishing location to another within the season. This movement of the fleet may confound any change in CPUE that may otherwise be detected. Attention was also drawn to results presented in WG-FSA-91/10.

7.113 Three types of analyses were attempted on the CPUE data from the longline fishery. Prior to 1989, most of the catch was taken by trawlers and these CPUE data are therefore not directly comparable to recent data. First, a simple deLury model (Chapman, 1972) with the assumption of constant recruitment was considered. This model (model 1) involves a simple linear regression of monthly CPUE on the catches, discounted for natural mortality (Appendix G).

7.114 Figures of these data show that the linear relationship between CPUE and discounted catches is very weak and suggest that the relationship may be curvilinear rather than linear. This is not surprising since it is well documented that CPUE (particularly from longline fisheries) may be related to the population abundance by a power function rather than a linear relationship (Mangel, 1985).

7.115 The second and third deLury type models were based on log transformations of the data and the following relationship between CPUE and population abundance,  $N$ :

$$CPUE_t = q.(N_t)^a$$

The second model (model 2) assumed  $a = 1$  (and is therefore similar to the first model, except for the fitting criterion used), whereas the third model (model 3) estimated an  $a$  value, as well as initial population abundance.

7.116 Figure 8 illustrates the log likelihood function for models two and three over a range of initial population sizes,  $N(1)$ . In both cases the likelihood curve is almost flat with respect to  $N(1)$  indicating a very bad fit of the model to the data. Figure 9 also illustrates that the fit of the model to the data is not very good and shows that there is not much difference between the model which assumes  $a = 1$  and that which estimates ' $a$ '. The estimated  $a$  value is 0.04. This value is so low that it suggests that there is very little relationship between CPUE and population size.

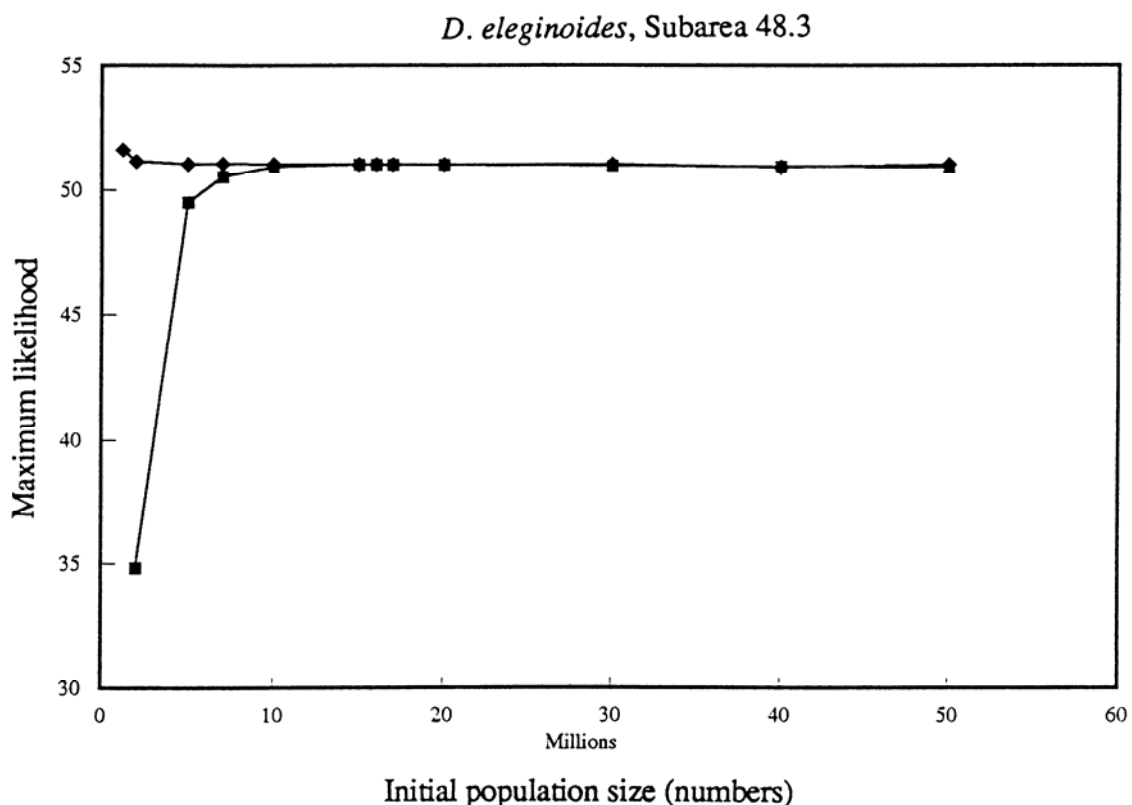


Figure 8: Log likelihood function for the model  $CPUE = qN^a$  where  $a = 1$  (—) and where  $a$  is fitted (---).

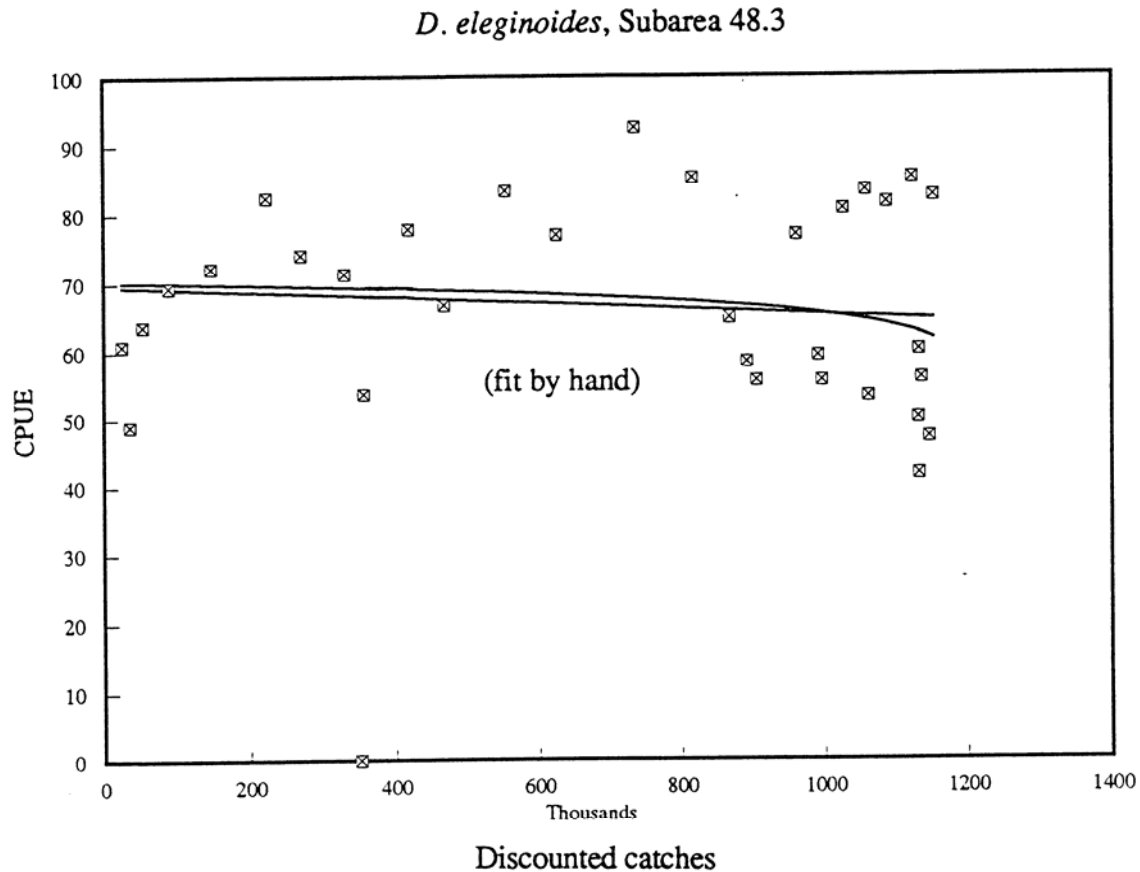


Figure 9: Maximum likelihood fit of the relationship between discounted catches and CPUE when modelled as  $CPUE = qN$  and  $CPUE = qN^a$ .

7.117 The Working Group also investigated the degree of correlation between the CPUE and discounted catches when only data from the most recent two years (1989/90 and 1990/91) or the single year (1990/91) were used with the simple, linear deLury model (model 1, Appendix G). The correlation coefficients were significant at the 5% level in both cases and the best fit was obtained when only one year's data were used.

7.118 Drs Gasiukov and Shust drew attention to the large discrepancies between the estimates derived from the two methods of calculation when using the data from the two year period (1989/90 and 1990/91) as opposed to one year (1990/91). It demonstrates that the method is highly sensitive to the input data which, in consequence, leads to a high degree of uncertainty in the results. The absence of sufficient robustness in the method means that it should not be used for practical calculations.

Table 7: Results of CPUE analysis using model 1. The regression is for CPUE in month t+1 (numbers/million hooks - see Figure 7), on discounted catches, **D(t)**, the sum (from month 1 to month t) of catches in numbers, discounted for natural mortality.

Data	Intercept	Slope	Correlation Coefficient	Sample Size	Significance Level
<b>M = 0.06</b>					
1989/90, 1990/91	82 899	-0.022	0.435	22	0.05
1990/91 only	88 126	-0.113	0.696	11	0.05
<b>M = 0.18</b>					
1989/90, 1990/91	83 370	-0.024	0.424	22	0.05
1990/91 only	88 461	-0.119	0.691	11	0.05
Estimates of initial biomass from the above analyses:					
	<b>M = 0.06</b>	<b>M = 0.18</b>			
Biomass July 1989	40 771	37 586			
Biomass July 1990	8 438	8 043			

7.119 Given the reservations expressed in paragraph 7.91 regarding the movement of the fishing fleet from one fishing location to another within Subarea 48.3, it would be more appropriate to analyse haul-by-haul data taking location into account. Although the submission of these data was required by Conservation Measure 26/IX they were not available to the Working Group. It is essential that the haul-by-haul data be submitted and analysed to investigate the spatial and seasonal variability. Standardisation of effort indices should also be attempted.

7.120 Table 8 summarises estimates of exploitable biomass and proposed catch levels for 1991/92 from assessments prepared by Members and those prepared at the meeting. It is important to note that those from the CPUE analysis can only be used as approximate estimates of current abundance since estimates relate to the biomass at the time of the first data point used in the analysis.

Table 8: Estimates of exploitable biomass (in tonnes) and proposed catch levels (in tonnes) for 1991/92.

	<b>M = 0.06</b>		<b>M = 0.18</b>	
	Biomass	Proposed catch	Biomass	Proposed catch
WG-FSA-91/20				
1989/90 survey	609 353	11 700	158 847	9 150
1990/91 survey	47 897	919	13 786	794
WG-FSA-91/24				
Cohort analysis			84 154	8 819
CPUE analysis				
Based on two years data	40 771	2 324	37 586	4 849
Based on one years data	8 438	481	8 043	1 037

NOTE: WG-FSA-91/20 catch levels based on MSY - calculations  
WG-FSA-91/24 catch levels based on  $F_{0.1}$  - calculations  
CPUE analysis catch levels based on  $F_{0.1}(M = 0.06) = 0.06$ ,  $F_{0.1}(M = 0.18) = 0.15$ .

7.121 A further caveat with respect to the CPUE analyses is that when applied to a data series which does not start at the beginning of exploitation, recruitment may be underestimated. If the ratio between the pristine population and that at the start of the data series can be assumed to be close to 1, this effect will be very small. At this stage there is not enough information available to determine what this ratio would be in the case of this species.

7.122 Calculations of  $F_{0.1}$  were used to estimate the expected ratio between yield (at  $F_{0.1}$ ) and the initial, unexploited, recruited biomass, as well as the equilibrium, exploited biomass. This allows calculation of the biomass levels that would be required to sustain a catch level of 9 000 tonnes per annum (Table 9).

Table 9: Standing stock to support a catch level of 9 000 tonnes, what do the UNEXPLOITED and EQUILIBRIUM EXPLOITED recruited biomass levels have to be to sustain this catch under  $F_{0.1}$ :

	$M = 0.06$ ( $F_{0.1} = 0.06$ )	$M = 0.18$ ( $F_{0.1} = 0.15$ )
UNEXPLOITED biomass	391 000	205 000
Equilibrium EXPLOITED biomass	158 000	70 000

NOTE: Age at recruitment = 8 years.

### Further Data Requirements

7.123 The Working Group did not have enough information to decide on the relative reliability of the different methods used to obtain biomass estimates for *D. eleginoides*. This implies that it is very difficult to make an objective decision about the reliability of the various biomass estimates in Table 8. The Working Group suggested that simulation studies to investigate the performance of different types of analyses should be conducted (also see paragraph 8.26).

### Management Advice

7.124 The wide range of estimates given in Table 8 reflects the large degree of uncertainty associated with the biomass level of *D. eleginoides* in Subarea 48.3.

7.125 It is important to note that the highest proposed catches (or TACs) are very close to the lowest estimates of biomass. It is obvious that if a high TAC is set when the actual biomass is relatively low, the stock may be seriously affected.

7.126 The range of possible estimates of TAC is listed in Table 8 and shown in Figure 10.

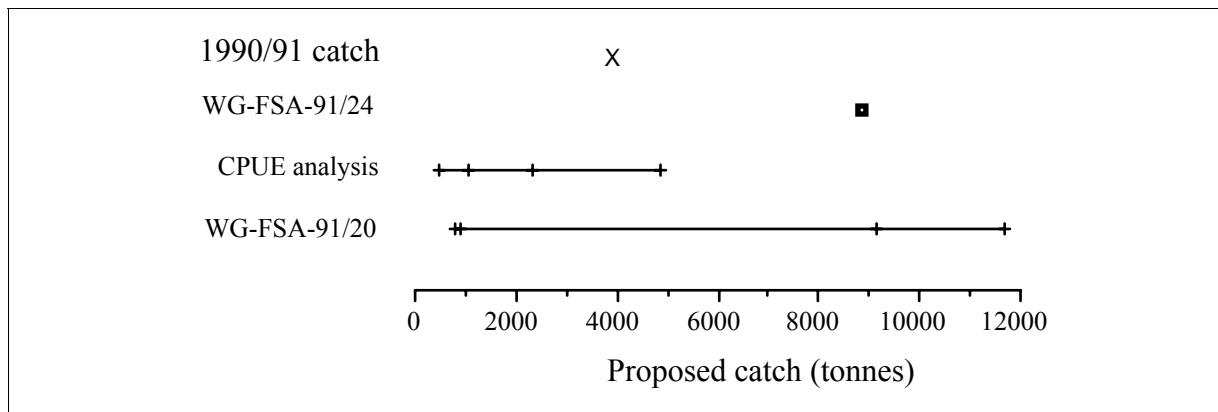


Figure 10: Ranges of proposed catches given in Table 8.

7.127 Drs Gasiukov and Shust stated that, as there is considerable uncertainty in the projection approach (WG-FSA-91/20) and the estimates based on analysis of CPUE data by the deLury method, the range of possible estimates of TAC should be as follows:

Higher	8 819 (WG-FSA-91/24)
1990/91 Catch	3 800

7.128 Other Members felt that there was at this stage no objective basis for preferring any specific part of the range (see paragraph 7.123).

#### *Electrona carlsbergi* (Subarea 48.3)

7.129 Catches of myctophids, consisting mainly of *E. carlsbergi*, have been reported from Subarea 48.3 since 1983 (see Figure 11). The Working Group noted the rapid expansion of the fishery since 1987. In the last year, 1990/91, the reported myctophid catch was 78 488 tonnes, a three-fold increase on the previous year.

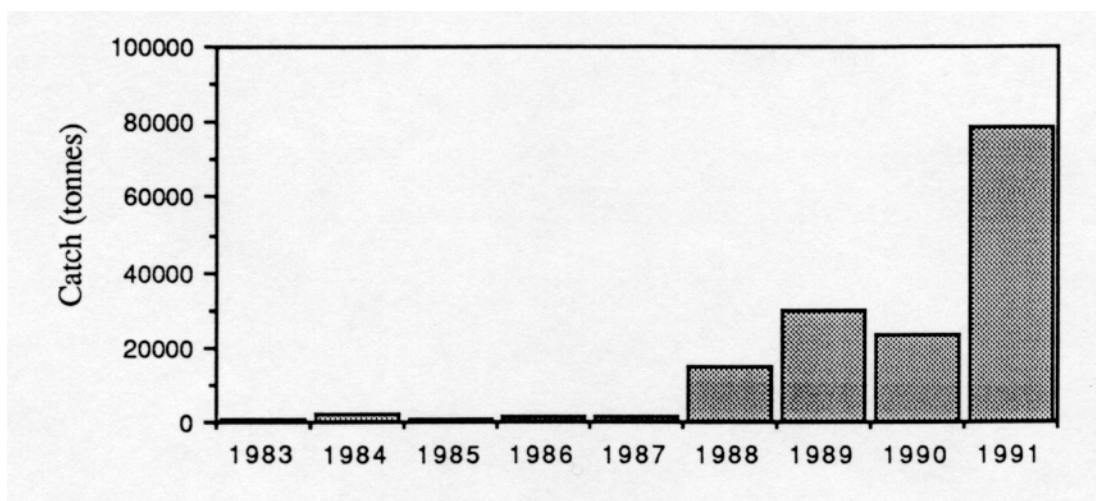


Figure 11: Catches of *E. carlsbergi* in Subarea 48.3.

7.130 Fine-scale data from 1988 and 1990 indicate that catches were concentrated around Shag Rocks and South Georgia respectively (CCAMLR-SB/91/3). In 1988 the concentration of catches was associated with a known concentration of myctophids over the shelf break at Shag Rocks (WG-FSA-90/19). The fine-scale data indicate that a similar occurrence may have occurred over the shelf break region to the northwest of South Georgia in 1990, although no survey data are available for this area. No fine-scale data has been submitted to CCAMLR for 1989 and 1991.

7.131 The length composition of the catch is available for 1990. This indicates that most *E. carlsbergi* caught in 1990 were between 60 and 80 mm in length. Length composition data from surveys in 1979 (WG-FSA-90/23), 1987/88 (WG-FSA-90/21) and 1989 (WG-FSA-90/21) show that fish of this species found in Subarea 48.3 have mostly been between 65 and 85 mm in length, corresponding to age class 2 (WG-FSA-90/21). Older fish are mostly found to the north of Subarea 48.3, north of the Polar Front (WG-FSA-90/21). The spawning stock consist of fish aged three and above. Consequently, the fishery is taking mostly juvenile fish.

7.132 The state of knowledge of this stock has been summarised in Annex 5, SC-CAMLR-IX. No other information on *E. carlsbergi* has been submitted since then. An assessment of potential yield from this fishery is presented below. A number of assumptions have had to be made due to the absence of important data or as a result of incomplete data.

## Recent Acoustic Surveys

7.133 Only one survey (1987/88) has been reported in Subarea 48.3. This survey concentrated in two areas, the first in the northwest quarter of Subarea 48.3 covering 60 000 square miles, and the second around Shag Rocks covering 7 200 square miles. The estimates for the two areas for myctophids generally were 1 200 000 tonnes and 160 000 tonnes respectively (WG-FSA-90/19). For the purposes of estimating catch levels, there are five major problems with these data:

- (i) there have been no biomass surveys since the escalation in fishing in 1988;
- (ii) there is little information on the spatial variability in the stock of *E. carlsbergi* during these surveys. The CV in these standing stock estimates is unknown;
- (iii) variation in recruitment is unknown. As a result, the biomass estimate could be substantially different from both the current abundance of the stock and the average unexploited biomass;
- (iv) the biomass in the Shag Rocks region is likely to have been overestimated due to non-random survey design in the form of a deviation from a straight line transect that followed the shelf break south of Shag Rocks, thus over-representing a high density patch of myctophids in the survey; and
- (v) although some information on the species composition of high density patches encountered during the acoustic surveys is presented in WG-FSA-90/19, there is no information on how myctophids were discriminated from krill in the acoustic data.

7.134 The biomass estimates provided in WG-FSA-90/19 have been used to calculate possible catch levels for this species. Although, these estimates do not have associated estimates of sampling variability, wide experience of acoustic surveying indicates that coefficients of variation in the range 0.1 to 0.5 are usual. For example, biomass estimates presented for acoustic surveys of krill ranged from 0.06 to 0.72 with a mean value of 0.36 (Post-FIBEX Acoustic Workshop, Table IX, *Biomass Report Series No. 40*). The CV of the myctophid biomass estimates was assumed to be 0.3.



## Stock Identity

7.135 Survey results indicate a predominance of immature fish south of the Polar Front and mature fish north of the Polar Front. There is no evidence to conclude that the immature stock of *E. carlsbergi* in Subarea 48.3 has become permanently isolated from the reproductive stock in the sub-Antarctic waters north of the Polar Front (SC-CAMLR-IX, Annex 5). Similarly, there is no evidence that these 2 year olds will not return to the spawning stock and reproduce in their lifetime. An alternative explanation could be that immature individuals become temporarily segregated from the adult stock as part of their life history in this region. Without evidence to substantiate the expatriation of 2 year olds from the reproductive stock or that these individuals will not reproduce in their lifetime, the Working Group assumed that the cohort of 2 year old *E. carlsbergi* within Subarea 48.3 comprised the complete age 2 cohort of the stock with full potential to reproduce as they grow.

## Y/R Analysis

7.136 Y/R analyses were carried out using the CCAMLR standard Y/R program. No direct observations on weight-at-age were available, and so these were estimated using length-at-age data and length-weight relationships. Two age/length keys from Subareas 48.4 and 48.6 were available in the CCAMLR database. As these did not appear to be calculated from data stratified by length, they were pooled and used to estimate the mean and variance of length-at-age. However, the distribution of lengths-at-age for age class 2 was wide and somewhat skewed, and this may be symptomatic of difficulties in age determination. The resultant means and SDs of length-at-age are given in Table 10. There were no distributions of length-at-age available for age classes 1 and 5+. For age class 1, the mean of all lengths-at-age 1 obtained from different samples (WG-FSA-90/21) was used and for the 5+ age class, the average of the  $L_{\infty}$  estimates was used.

Table 10: Weights-at-age for *E. carlsbergi* in Statistical Area 48.

	a (x 10 <sup>-5</sup> )	b	1	2	Age 3	4	5+
Length - mean (mm)			47.90*	77.82	85.22	90.67	95.00 <sup>+</sup>
SD			-	5.10	3.38	2.33	-
Weight (1) (gm)	2.081	2.94	1.81	7.64	9.91	11.90	13.58
Weight (2) (gm)	1.704	2.99	1.80	7.79	10.14	12.21	14.00
Weight (3) (gm)	4.596	2.75	1.92	7.37	9.40	11.15	12.62
Weight (4) (gm)	5.947	2.70	2.05	7.66	9.74	11.52	13.01

\* Length = Mean for age 1 from Table 3 of WG-FSA-90/21

<sup>+</sup> Length = Mean of  $L_{\infty}$  from Table 4 of WG-FSA-90/21

7.137 Weight-length relationships were available in WG-FSA-90/21, by sex for Antarctic and sub-Antarctic samples. The mean weights-at-age (**W**) were estimated by the following formula:

$$W = aL^b + 0.5s^2ab(b-1)L^{b-2}$$

where **L** and **s** are the mean and SD of the length-at-age respectively. The values of **a** and **b** are from WG-FSA-90/21 and reproduced in Table 10 along with the four resultant sets of weight-at-age. The four different sets were used in the Y/R analysis to determine the sensitivity of the results to uncertainty in weight-at-age.

7.138 The value of natural mortality used was **M** = 0.86, given in WG-FSA-90/23. The sensitivity of the results to uncertainty over **M** was examined using **M** = 0.65 and **M** = 0.9 (the Y/R program was not able to obtain solutions for **M** higher than 0.9). Fishing mortality was assumed to apply to only 2 and 3 year old fish, with relative selectivities 1.0 and 0.2 respectively.

7.139 The results of the Y/R analysis are given in Table 11. It is clear that the values of **F**<sub>0.1</sub> are very high, and would result in heavy depletion of the spawning stock-per-recruit, with a consequent high probability of recruitment failure. Basing TACs on **F**<sub>0.1</sub> for this species is not an appropriate management policy. Accordingly, it was decided to calculate TACs using the fishing mortality for which the spawning biomass per recruit would be reduced to 50% (**F**<sub>50%SSB</sub>). This average level of spawning stock escapement should be sufficient to avoid declines in recruitment. The total stock biomass would average about 80% of the mean unexploited biomass. This should limit the impact of the fishery on dependent predators. A lower **F** value is also preferred in short-lived fish so as to reduce the possibility of stock collapse due to fluctuations in recruitment.

Table 11: Summary of Y/R analysis.

Weight Curve	<b>M</b>	<b>F</b> <sub>0.1</sub>	SSB*	<b>F</b> <sub>50%SSB</sub>
(1)	0.86	2.825	5%	0.64
(2)	0.86	2.825	5%	0.64
(3)	0.86	2.825	5%	0.64
(4)	0.86	2.825	5%	0.64
(1)	0.65	2.525	6%	0.62
(1)	0.90	2.825	5%	0.64

\* Spawning stock biomass-per-recruit as a percentage of the level in the unexploited stock

7.140 The values of  $F_{50\%SSB}$  for the different sets of weight-at-age and  $M$  values are also given in Table 11. These values are robust against the apparent uncertainty in weight-at-age and against a range of values of  $M$ . TACs are calculated using  $F_{50\%SSB} = 0.64$ .

#### Calculation of TAC

7.141 TACs are calculated for the two geographic scales for which there are estimates of stock biomass. The smaller scale covers the region around Shag Rocks, where there is a concentration of fish over the shelf break. The second scale covers the larger survey which covered a substantial proportion of Subarea 48.3. However, the region around South Georgia, where the fishery concentrated in 1990, has not been covered in either survey.

7.142 For each geographic scale, TACs have been calculated for a range of probabilities that the fishing mortality would exceed the selected level. The results are presented in Table 12. Because of uncertainty in the estimate of stock size, a given calculated TAC will not result in exactly the intended fishing mortality. The table shows for example, that if a TAC for the large area of Subarea 48.3 was set at 398 000 tonnes, there would be a 50% probability that the intended fishing mortality would be exceeded. On the other hand, if that TAC was set at 245 000 tonnes, the probability of exceeding the intended fishing mortality would be only 5%.

Table 12: Calculated TACs for *E. carlsbergi* in Subarea 48.3, for various probabilities that the given TAC will result in fishing mortality exceeding the intended value (0.64), for the two survey biomass results. The 1 200 kilotonne survey applies to a large proportion of Subarea 48.3, while the 160 kilotonne estimate applies to a restricted region around Shag Rocks.

Probability	TAC for 1 200 kt Biomass	TAC for 160 kt Biomass
5%	245	32.7
10%	273	36.3
20%	310	41.4
30%	341	45.5
40%	369	49.2
50%	398	53.0
60%	428	57.1
70%	463	61.7
80%	509	67.8
90%	579	77.2
95%	643	85.8

## Management Advice

7.143 The basic data available to assess the stock in Subarea 48.3 are incomplete, and therefore considerable uncertainty surrounds the assessment. The catches in the fishery have expanded threefold since 1990, from 23 623 to 78 488 tonnes. Fine-scale catch and effort data were not available to the Working Group in time to be used in the assessments. Analyses of biological data have been reported in papers to the Working Group, but the data have not yet been submitted for inclusion in the CCAMLR database. The Working Group urges that these data be submitted.

7.144 An analysis of Y/R shows that the management policy of setting TACs based on  $F_{0.1}$  is not appropriate for this fishery. A level of fishing mortality which allows 50% escapement in the spawning stock has been used to calculate a range of possible TACs (given in Table 12). These TACs have been calculated to allow for uncertainty in survey biomass estimates to be taken into account by the Commission when setting the TAC. If a TAC were to be based on the large-scale survey, and such catches were to be taken, they should be distributed over the area, and not be entirely taken out of one or two concentrations of fish. If only the concentrations near the island shelf breaks are to be fished, considerably lower TACs (of the order of magnitude illustrated by the Shag Rocks assessment) should be set, so as to limit the impact of the fishery on local predators.

7.145 In view of the Commission's request for advice on the potential yield of the fishery as a matter of urgency (CCAMLR-IX, paragraph 4.27 - but see also discussion under Data Requirements, paragraphs 8.7 to 8.8 below), some Members viewed the assessment presented here as being the best scientific evidence available on the potential yield of *E. carlsbergi* in Subarea 48.3. Given the unquantified uncertainties they felt that initial TACs should be set at the low end of the ranges in Table 12. This is also important because of the scarcity of information on the possible effects of the fishery on dependent predators.

7.146 Dr Shust indicated that in his view significant uncertainties are associated with flux factors affecting the distribution of the *E. carlsbergi* stock in the area concerned. Such fluxes would affect the estimation of the available standing stock due to concentration of fish in the region as well as the possible incursion of fish from elsewhere (e.g. from north of the Polar Front). Current biomass estimates would underestimate the stock size as the total distribution range of the stock is unknown, although it is larger than the area surveyed.

7.147 In reply, other members of the Working Group pointed out that the estimation of flux factors in mobile species such as *E. carlsbergi* is difficult and may take some time. Consequently, considerable uncertainty is likely to be associated with the dynamics of the stock for some time to come. Given the situation, the majority of Working Group members favoured a conservative approach to the setting of catch levels for this species. They noted that some attempt had been made to take flux factors into account in the calculations of the TACs (paragraphs 7.142 to 7.144 above) by assuming that the biomass estimate applied to only part of the stock.

7.148 Since the fish are taken with small mesh nets (about 25 mm) in near shelf waters, there is a possibility that juvenile fish of other species will be taken as a by-catch. Information on any such by-catch should be reported, using protocols similar to those for the krill fisheries.

7.149 If the fishery is to continue at the high level of the last season, it is recommended that further surveys be conducted in order to improve biomass estimates and to begin to assess the level of recruitment variability in the stock. These surveys should also cover the region around South Georgia. Further attention should be paid to the design and conduct of the surveys to ensure that a proper random design is followed. The surveys should also be designed to identify the distribution and structure of the stock in relation to the Polar Front and other subareas.

7.150 The Working Group reiterates the request from last year (SC-CAMLR-IX, Annex 5, paragraph 183) that a high priority should be given to developing a methodology for the design of myctophid biomass surveys and the subsequent analysis of data. The Working Group noted that it may be possible to draw on the developments in this area by WG-Krill. Further problems that need to be addressed in these acoustic surveys are the need to determine the acoustic target strength for myctophids and the development of routine techniques for discriminating between myctophids and krill in acoustic data.

#### *Notothernia gibberifrons* (Subarea 48.3)

7.151 Total catches of *N. gibberifrons* decreased from 838 tonnes in 1988/89 to 11 tonnes in 1989/90 and to only 3 tonnes in 1990/91. Decreased catches were due to prohibition of directed fishing on this species (Conservation Measure 22/IX) and a prohibition of bottom trawling in the subarea (Conservation Measure 20/IX) rather than reduced abundance (see

below). During 1989/90 and 1990/91, no commercial landings of *N. gibberifrons* were reported, the entire catches were taken during research fishing.

7.152 Since there were no commercial catches reported using semipelagic trawls, no new information on by-catches of *N. gibberifrons* in the *C. gunnari* fishery could be made available to the Working Group as offered at the Ninth Meeting of the Commission (CCAMLR-IX, paragraph 13.16 and paragraph 8.10 of this report).

7.153 Trawl survey biomass estimates useful for assessment purposes were available for 1984/85 and 1986/87 to 1990/91 (WG-FSA-91/14 and WG-FSA-91/23). Surveys conducted during other years were judged to be less reliable for *N. gibberifrons* because of sampling problems or because no CV was available.

7.154 As indicated in Table 13, two biomass estimates were available for 1989/90 and 1990/91 and were averaged for assessment work. Where available, survey biomass estimates for the Shag Rocks area and the rest of Subarea 48.3 were combined.

Table 13: Survey biomass of *N. gibberifrons*.

Year	Subarea 48.3	CV (%)	Shag Rocks	CV (%)	Total	CV (%)
1984/85	15 762	28	-	-	15 762	28
1986/87	13 544	15	363	45	13 907	15
1987/88	7 189	13	609	10	7 798	12
1988/89	8 510	17	-	-	8 510	17
1989/90	12 417	28	267	39	12 684	27
1989/90	21 891	23	-	-	21 891	23
Average for 1989/90					17 288	18
1990/91	28 224	18	117	34	28 341	18
1990/91	22 541	12	-	-	22 541	12
Average for 1990/91					25 441	11

7.155 A re-analysis of data used for last year's assessment was presented to the Working Group in WG-FSA-91/26. The analyses in WG-FSA-91/26 used two different approaches to tuning VPAs for *N. gibberifrons*. The first approach treated survey biomass estimates as measures of absolute abundance (the 'survey  $q = 1$ ' approach) while the other treated survey biomass estimates as measures of relative abundance (the 'survey  $q \neq 1$ ' approach). Survey  $q$ , in this context, is the constant of proportionality that relates survey estimates to absolute biomass (i.e. survey biomass \* survey  $q$  = absolute biomass).

7.156 Some Members felt that an 'added sums of squares test' could be used to determine if the 'survey  $q \neq 1$ ' model in WG-FSA-91/26 was significantly better than the 'survey  $q = 1$ ' model.

7.157 Other Members felt that this test was invalid.

7.158 There was also some disagreement about the degrees of freedom associated with the two models and required for the test. Dr Gasiukov expressed the opinion that both models ( $q = 1$  and  $q \neq 1$ ) have the same degrees of freedom. Other Members said that this is not the case and that the model assuming  $q \neq 1$  has one less degree of freedom than that assuming  $q = 1$ .

7.159 The results from the test are presented in the table below. Sums of squares and degrees of freedom for the survey  $q = 1$  and survey  $q \neq 1$  models were obtained from Table 3 in WG-FSA-91/26. The result ( $F = 0.89$ ), which follows the  $F$  distribution with 1 and 3 degrees of freedom, was not statistically significant. According to this test, the survey  $q \neq 1$  model was not significantly better than the survey  $q = 1$  model.

Model	Degree of Freedom	Sum of Squares	Mean Square
$q = 1$	4	1.85	0.46
$q \neq 1$	3	1.44	0.48
$F = (1.85 - 1.44) / 0.46 = 0.89$			

7.160 Dr Gasiukov argued that the two models have the same degrees of freedom because  $q$  is a function of the unknown parameter ( $N_{at}$  or  $F_{ay}$ ) in the terminal year. In this case the same table would be:

Model	Degree of Freedom	Sum of Squares	Mean Square
$q = 1$	4	1.85	0.46
$q \neq 1$	4	1.44	0.36

This shows that the final mean square estimate is almost 25% less when  $q \neq 1$  than when  $q = 1$ .

7.161 Work performed at the meeting was based on the data presented in WG-FSA-91/26 and biomass estimates from bottom trawl surveys in 1990/91 (see paragraph 7.155 above). Two approaches, one assuming survey  $q = 1$  and the other assuming survey  $q \neq 1$ , were used to obtain biomass estimates of *N. gibberifrons* during 1990/91 and TACs for 1991/92. There were minor differences between the models and those in WG-FSA-91/26 due to software availability but these differences had little impact on results (this was verified by testing models on data in WG-FSA-91/26).

7.162 Natural mortality was assumed to be 0.125 in all analyses. Ages 2 to 16 were included and age 16 was not treated as a ‘plus group’.

7.163 The survey  $q = 1$  model was fitted by adjusting the terminal  $F$  in a traditional VPA until the sum of squared differences between log predicted biomass and log survey biomass estimates was minimised. Partial recruitment of young fish to the fishery was assumed to be the same as in WG-FSA-91/26 and prior analyses (partial recruitment = 0.2, 0.3, 0.5, 0.7 and 0.8 and 1.0 for ages 2 to 7+).

7.164 The survey  $q \neq 1$  model was fitted using the Laurec-Shepherd algorithm tuned to effective fishing effort data. Effective fishing effort was estimated from the ratio of total landings and survey biomass and then used to construct indices of abundance for all age classes (2 to 16) in the analyses. Inverse SDs (scaled to 1.0 in 1990/91) from the survey biomass estimates were used in the Laurec-Shepherd algorithm to weight the fishing effort data for individual years (Table 14). Inverse SDs, rather than inverse variances, were used as weights because variances resulted in too great a disparity among weights for different years.

Table 14: Input values for the VPA tuned to survey biomass converted to effective effort.

Year	Survey Biomass	Total Landings	Effective Effort	Weighting Factor
1984/85	15 762	2 081	0.132	0.66
1986/87	13 907	2 844	0.205	1.4
1987/88	7 798	5 222	0.670	3.1
1988/89	8 510	838	0.0985	2.0
1989/90	17 288	11	0.000636	0.95
1990/91	25 441	3	0.000118	1.0

7.165 Some Members felt that weighting by the inverse square of the CV would have been more appropriate because of the positive relationship between the magnitudes of variance and that of the survey biomass estimate that is often observed (Hennemuth, 1976).

7.166 The Laurec-Shepherd algorithm used for the survey  $q \neq 1$  approach was applied to biomass indices for 15 age classes. This meant that 15 values of  $q$  (one for each age class) were estimated. The algorithm does not output a single value of  $q$  comparable to that in WG-FSA-91/26 (see paragraph 7.154 above) but a value was readily obtained from the output using:

$$\hat{q} = \exp \left[ \left( \sum \ln I_t - \sum \ln A_t \right) / N \right],$$



where  $I_t$  is predicted biomass from the model for year  $t$ ,  $A_t$  is survey biomass in year  $t$  and  $N = 6$  is the number of years with survey biomass estimates. The formula was obtained by differentiating the sum of squared differences between log predicted biomass and log survey biomass estimates with respect to  $q$ , setting the result equal to zero and solving for  $q$ .

7.167 Parameter estimates for the two models were:

	$q = 1$	$q \neq 1$
Survey $q$	-	1.23
1990/91 $\bar{F}$ (mean ages 2 to 15)	0.0002	0.0004

The estimate of survey  $q = 1.23$  indicates that total biomass levels are, on average, 23% larger than survey biomass estimates.

7.168 Estimates of biomass, fishing mortality and recruitment obtained using the two approaches were similar for years up to 1987/88 but diverged in later years (Table 15 and Figure 12).

Table 15: Biomass, mean fishing mortality and recruitment of *N. gibberifrons* from VPA runs with  $q = 1$  and  $q \neq 1$ .

Year	$q = 1$			$q \neq 1$		
	Biomass	$\bar{F}_p$	Recruits	Biomass <sup>1</sup>	$\bar{F}_p$	Recruits <sup>1</sup>
1985/86	12 745	0.10	25 069	10 878	0.11	31 235
1986/87	14 029	0.11	24 387	12 216	0.12	45 017
1987/88	14 167	0.20	24 079	13 483	0.19	64 611
1988/89	11 422	0.09	21 474	13 583 (11 895)	0.09	82 811 (16 533)
1989/90	13 639	0.01	27 451	21 569 (18 427)	0.02	135 505 (16 533)
1990/91	17 135	0.0001	24 664	43 168 (30 919)	0.0003	425 386 (16 533)

<sup>1</sup> Figures in brackets are revised values

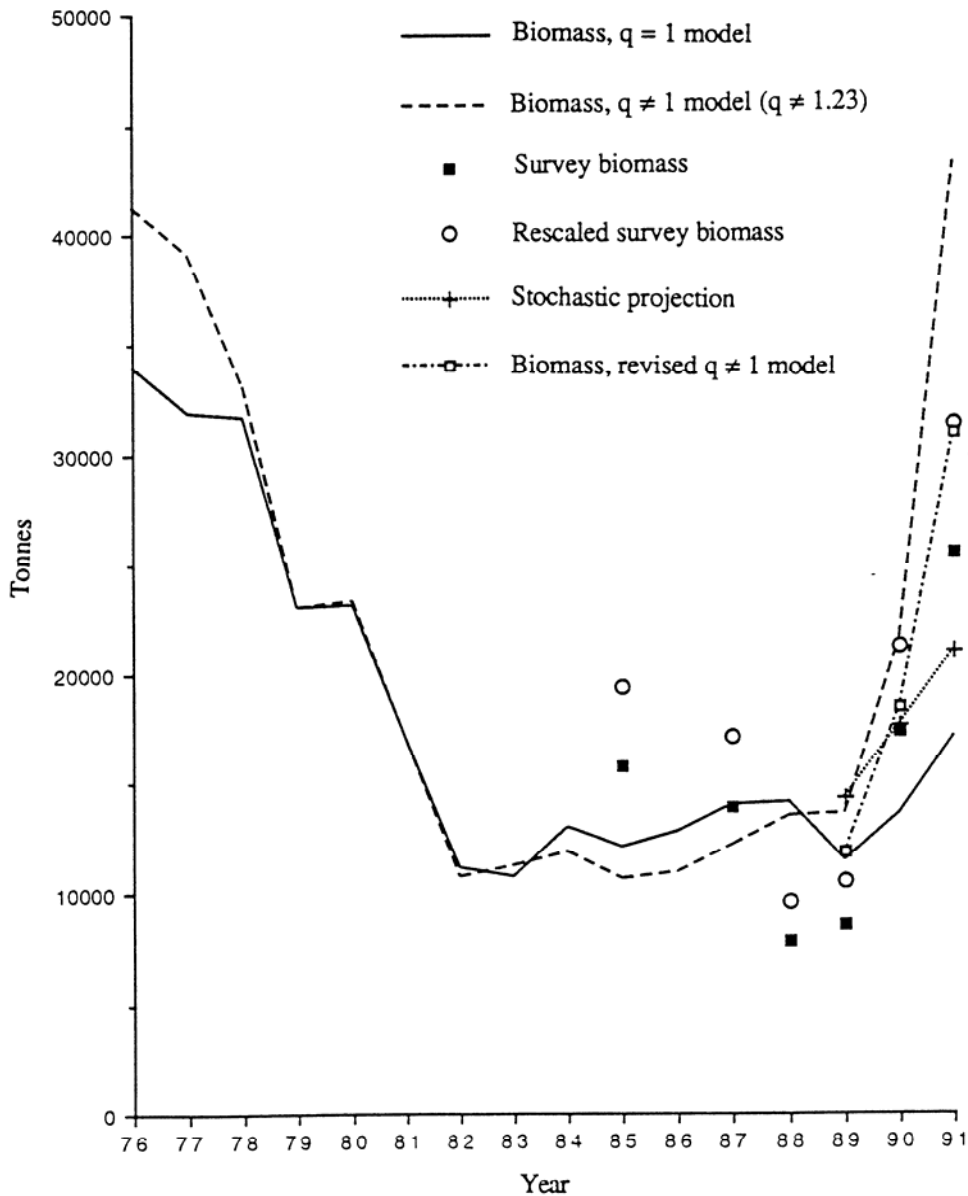


Figure 12: Biomass estimates for *N. gibberifrons* in Subarea 48.3 from the survey  $q = 1$  and  $q \neq 1$  ( revised and original) models. Survey biomass estimates are given in original and rescaled (divided by the survey  $q = 1.23$ ) units. The scaling factor adjusts survey biomass estimates to match VPA biomass estimates from the  $q \neq 1$  model. Also shown are results from a stochastic simulation for 1988/89 to 1990/91 (see paragraph 7.174).

7.169 There were significant differences between the biomass estimates for 1989/90 and 1990/91 obtained using the survey  $q = 1$  and survey  $q \neq 1$  models due to differences in recruitment estimates for later years. In particular, very large recruitment estimates for 1989/90 to 1990/91 from the survey  $q \neq 1$  model resulted in very large biomass estimates for these years.

7.170 Some Members suggested that this problem may have been due to the use of research survey age composition data in recent years when total catches were very low since the Laurec-Shepherd algorithm assumes constant age partial recruitment patterns over time.

7.171 The Working Group recognised that recruitment estimates obtained from VPA analyses for recent years are often unreliable and decided to substitute average recruitment during 1975/76 to 1987/88 for recruitments during 1988/89 to 1990/91 estimated directly by the VPA. It was not necessary to make this correction to estimates of recent biomass from the survey  $q = 1$  model because they were similar to the average for earlier years.

7.172 A simulation procedure (parametric re-sampling, Efron, 1982) was used to estimate a 95% confidence interval for the estimate of survey  $q$  from the Laurec-Shepherd procedure. First, predicted biomasses were obtained from the model fitted to the original data. Fifty sets of simulated effort data were then obtained by converting predicted population biomass levels to predicted survey biomass levels (survey biomass = population biomass / 1.23) and multiplying each predicted survey biomass by a random number. Random numbers were log-normally distributed with mean zero and log scale variance chosen to match the arithmetic CVs reported for the original survey biomass estimates.

7.173 The SD for the estimate of survey  $q$  from the re-sampling procedure was 0.50 and the 95% interval ranged from 0.23 to 2.23. The relatively large size of the confidence interval indicates that the estimate of survey  $q$  was imprecise and the fact that the confidence interval included 1.0 indicates that the survey  $q \neq 1$  model was not significantly better than the  $q = 1$  model for *N. gibberifrons* given current data.

7.174 The CCAMLR stochastic population projection program was used to determine the maximum rate at which *N. gibberifrons* in Subarea 48.3 could have increased from the low level in 1987/88. Recruitments for simulations were obtained by bootstrapping recruitment estimates from the survey  $q = 1$  model for 1975/76 to 1988/89. Initial numbers of fish in each age group during 1987/88 (needed to start the projection) were taken from the survey  $q = 1$  model. As indicated above, both the survey  $q = 1$  and the  $q \neq 1$  models gave similar recruitment and abundance estimates up to 1988/89. Fishing mortality in 1988/89 to 1990/91 was assumed to have been very low (0.0001) to enable the population to grow at its maximum rate. Age-specific maturity, partial recruitment, and weight data were the same as used in the two VPA models.

7.175 Mean simulated population biomass in 1990/91 (21 081 tonnes, 1 000 simulations) was in closer agreement with the biomass estimate from the survey  $q = 1$  model than with the estimate from the survey  $q \neq 1$  model (Figure 12). This result lends some additional support to the biomass estimate for 1990/91 from the survey  $q = 1$  model.

7.176 Standard CCAMLR software was used to estimate biomass and TACs for 1991/92 assuming: (i) age specific partial recruitments described above, (ii)  $F_{0.1} = 0.0935$ , (iii)  $M = 0.125$  and (iv) average recruitment of two year olds during 1991/92. Two scenarios were considered, one with age specific biomasses for 1990/91 and mean recruitment from the survey  $q = 1$  model and the other with age specific biomass levels for 1990/91 and mean recruitment from the survey  $q \neq 1$  model.

	$q = 1$	$q \neq 1$
Mean recruitment	19 718	16 533
Biomass 1990/91	17 135	30 919
Biomass 1991/92	20 867	57 945
TAC for 1991/92	1 502	3 025

#### Management Advice

7.177 Members of the Working Group could not agree on which assessment model was more reliable and which level of TAC for *N. gibberifrons* should be recommended for 1991/92. Some thought that a TAC of 1 502 tonnes from the  $q = 1$  model was most appropriate while others thought that a TAC of 3 025 tonnes from the  $q \neq 1$  was most appropriate.

7.178 It was agreed, however, that the TAC could only be obtained by bottom trawling which would result in by-catch of other species in Subarea 48.3 (see paragraphs 7.189 to 7.197). It was also agreed that the potential effects on other species should preclude direct fishery by any fishing method for *N. gibberifrons* in 1991/92. Some Members felt the by-catch in the pelagic fishery for *C. gunnari* should be limited to 500 tonnes of *N. gibberifrons* (see Conservation Measure 20/IX).

7.179 Dr Shust suggested that in view of the calculation of the TAC based on the  $q = 1$  model, a by-catch limit of 1 500 tonnes could be recommended.

*Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* (Subarea 48.3)

7.180 Reported catches of both species have been only several tonnes since 1989/90 in accordance with conservation measures set by the Commission allowing only a by-catch of 300 tonnes of each of the two species. Prior to this regulation of the fishery, catches of these two species have only been reported by Poland, the German Democratic Republic and Bulgaria, but never by the Soviet Union, although the species were a regular by-catch in the bottom trawl fishery. In 1990, the Working Group attempted to reconstruct the fishery by re-allocating 75% of the catch of 'Pisces nei' reported by the Soviet Union to the two species in the same proportion as these species were reported in the Polish catches (see SC-CAMLR-IX, Annex 5, paragraphs 191 to 197).

7.181 VPA analysis in 1990 suggested that both stocks reached their lowest level of abundance in 1987 and increased in size from then, in particular since 1989/90. This upward trend is also apparent from the two biomass estimates available from the 1990/91 season:

*C. aceratus*

13 474 tonnes (CV 15%) (Falklands Protector, WG-FSA-91/14)

18 022 tonnes (CV 15.3%) (Atlantida, WG-FSA-91/23)

*P. georgianus*

13 948 tonnes (CV 19%) (Falklands Protector, WG-FSA-91/14)

9 959 tonnes (CV 15.4%) (Atlantida, WG-FSA-91/23).

This upward trend in stock sizes is likely to be due to the prohibition of bottom trawling in Subarea 48.3 (Conservation Measure 20/IX) and the resulting low or negligible by-catch of these species in the pelagic fishery and the prohibition of a directed fishery on these species (Conservation Measure 22/IX).

7.182 Although biomass estimates were similar, length compositions show considerable differences between the two surveys, in that the proportion of sexually mature fish in the catch was much higher for both species in the *Falklands Protector* survey than in the *Atlantida* survey (see Figures 13 and 14). The most likely reason is that the *Atlantida* survey which took place during the spawning season in April and May, missed part of the spawning stock which had migrated inshore for spawning.

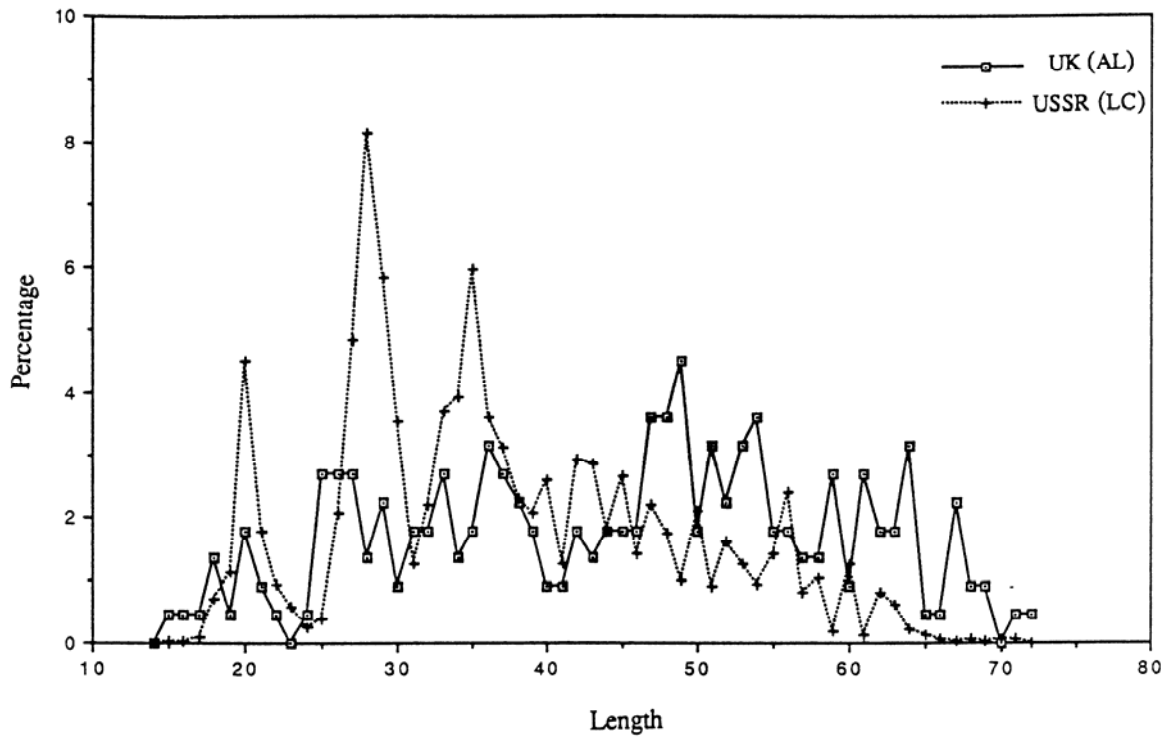


Figure 13: Length frequency *C. aceratus* from *Falkland Protector* (UK) and *Atlantida* (USSR) surveys.

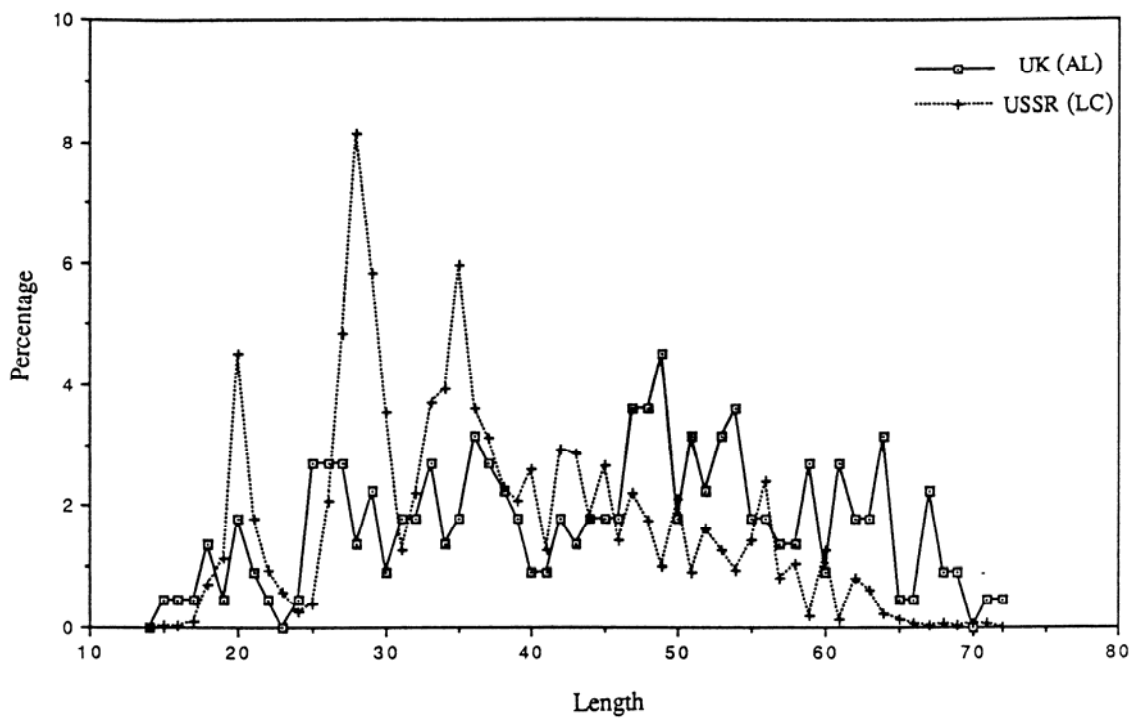


Figure 14: Length frequency *P. georgianus* from *Falkland Protector* (UK) and *Atlantida* (USSR) surveys.

7.183 Allowing for an under-representation of spawners in the *Atlantida* survey, the two biomass estimates for *P. georgianus* appear to be very similar while the difference between the two stock size estimates for *C. aceratus* is likely to be larger than apparent from a figure of 5 000 tonnes alone.

7.184 Given these reservations, the biomass estimates suggest that current stock sizes are 30% of the initial level in *P. georgianus* and 80 to 90% in *C. aceratus* (see SC-CAMLR-IX, Annex 5, paragraphs 200 to 201).

#### Management Advice

7.185 To estimate potential yield for the 1991/92 season projected catches for the 1990/91 season (SC-CAMLR-IX, Annex 5, Tables 9 and 10, p. 196) were adjusted in proportion to the difference of the 1990 and 1991 research vessel surveys. The multiplication factors and the projected catches at  $F_{0.1}$  (and also 50% of  $F_{0.1}$  in *P. georgianus*) were:

Species	Multiplication Factor	Projected Catch 1991/92 (tonnes)
<i>P. georgianus</i>	1.33	4 756
<i>P. georgianus</i>	50% $F_{0.1}$ 1.33	2 717
<i>C. aceratus</i>	1.1	1 757

7.186 However, as the new information available did not allow for refinement of the 1990 analysis, the Working Group reiterated two important conclusions from the 1990 meeting:

- (i) the outcome of the analysis of *P. georgianus* was largely affected by the reliability of ageing in this species. If the true growth rate of this species is much lower than assumed in the 1990 analysis, as some investigations from the 1970s suggested, this could change estimates of  $M$ ,  $F_{0.1}$  and recruitment considerably (SC-CAMLR-IX, Annex 5, paragraph 206); and
- (ii) the stock of *C. aceratus* appears to be very vulnerable to overfishing at relatively low levels of fishing effort. The spawner-recruit relationship and low initial stock size suggest that stock may not sustain a high yield when it recovers (SC-CAMLR-IX, Annex 5, paragraph 207).

7.187 Given the uncertainties surrounding estimates of  $F_{0.1}$ , recruitment and mortality, particularly in *P. georgianus*, management at  $F_{0.1}$  for both stocks appears to be inappropriate at the present stock size. As neither species can be taken without a significant by-catch of other species, such as *N. gibberifrons*, a possible reopening of a directed fishery on these species would bear implications for other species which have to be taken into account. This is presented in more detail below (paragraph 7.194 to 7.196).

7.188 It is therefore recommended that the current prohibition of a directed fishery and a by-catch provision continue to be applied to these two species. Most Members felt that this should be at the current level of 300 tonnes for each species. Dr Shust suggested that in light of the trend in biomass, it should be increased to 500 tonnes for each species.

#### General Management Advice (Subarea 48.3)

##### General Considerations on the Re-opening of a Directed Fishery and the Application of TACs to 'By-catch' Species in Subarea 48.3

7.189 Since 1989, the Commission has implemented conservation measures which prohibited:

- the use of bottom trawls in the subarea;
- directed fishing on the 'by-catch' species *N. gibberifrons*, *P. georgianus* and *C. aceratus*; and
- the catch of more than 500 tonnes of *N. gibberifrons* and 300 tonnes each of *P. georgianus* and *C. aceratus* as by-catch in the fishery on *C. gunnari*.

7.190 Reported catches of all three species have become negligible since then.

7.191 All three stocks exhibited an upward trend in stock size since 1989 which is likely to be attributable to the conservation measures implemented by the Commission.

7.192 Although stocks of *N. gibberifrons* and *P. georgianus* appear still far from having recovered, a re-opening of the fishery on one or all of these species might be considered. As this is likely to occur by bottom trawling, the possible effect of bottom trawling on target and



by-catch species has been reconsidered by the Working Group (see also SC-CAMLR-VII, Annex 5, paragraph 65).

7.193 Due to the under-reporting or non-reporting of these species by the Soviet fishery, the Working Group was able only to utilise data from the Polish bottom trawl fishery from 1980 to 1982 and 1985 to 1988. This was combined with estimates of potential yields at  $F_{0.1}$  and  $F_{max}$  based on previous analyses of the Working Group to investigate the total potential yield from a mixed demersal fishery in Subarea 48.3.

7.194 The mean ratios of *C. aceratus*, *P. georgianus* and *N. gibberifrons* in bottom trawl catches in the years when the fishery targetted on *C. gunnari* were approximately 1:1:1:6 (see Appendix H), i.e. a catch of any one of the species *N. gibberifrons*, *P. georgianus*, *C. aceratus* would result in an equal proportion of the others and a six-fold proportion of *C. gunnari*. The Working Group noted that the ratios had changed from year to year.

7.195 Using estimates of age-at-recruitment, **K** and **M** contained in WG-FSA-91/15 and WG-FSA-90/6, values of  $\lambda$  (Table 2 of Beddington and Cooke, 1983) were interpolated and applied to estimates of total unexploited biomass (Appendix H). Values of  $\lambda$  give the estimated MSY as a proportion of total unexploited biomass. These are shown, together with current sustainable yields at  $F_{0.1}$  given in the previous sections (see paragraph 7.176 and 7.185), in Table 16.

Table 16: MSY and 1992 yield ( $F_{0.1}$ ) for demersal species in Subarea 48.3.

Species	$\lambda$	Potential MSY (tonnes)	Current Yield $Y_{(F_{0.1})}$ (tonnes)
<i>C. aceratus</i>	0.118 - 0.127	2 124 - 2286	1 757
<i>P. georgianus</i>	0.18	7 920	4 756
<i>N. gibberifrons</i>	0.035	1 470	1 502 - 3 025

7.196 In any mixed bottom trawl fishery where catches are at  $F_{0.1}$  (the agreed policy of the Commission) or  $F_{max}$ , the TAC of *N. gibberifrons* will be reached first if catches of the various species remain in similar proportions to those calculated from Polish catches (i.e. the TAC of *N. gibberifrons* is limiting). The sustainable yield of the target species *C. gunnari* from a bottom trawl fishery therefore cannot be higher than six times the TAC for *N. gibberifrons* (8 800 tonnes at  $F_{max}$ ). If that fishery is targetting *C. gunnari*, the MSY from the fishery including all species would be about 13 000 tonnes under the most favourable circumstances, and would likely be much less given the uncertainties surrounding these

estimates and the adverse effects of bottom trawling on benthos which may affect fish communities in the medium or long-term, e.g. by habitat destruction (see WG-FSA-90/24).

7.197 Given the low current yield ( $F_{0.1}$ ) and potential yield (MSY) of a bottom trawl fishery in Subarea 48.3, the uncertainties surrounding the ratios of the species in catches of mixed fishery and in stock size estimates and the potentially adverse effects of habitat destruction, the Working Group recommended that the prohibition of bottom trawling should remain in force.

#### South Orkney Subarea (48.2)

7.198 Catches in Subarea 48.2 were only high in the 1977/78 season, when 140 000 tonnes were taken (almost exclusively *C. gunnari*). Catches reported for the subarea in subsequent years have been in the order of a few thousand tonnes, except in 1982/83 and in 1983/84, when 18 412 and 15 956 tonnes were caught. *C. gunnari* and *N. gibberifrons* have been so far the most abundant species in the catches. Catches reported as *Pisces nei* were composed of different species of channichthyids (mainly *C. aceratus*, *Chionodraco rastrospinosus* and *P. georgianus*) and *Notothenia kempfi*, but may have also been *N. gibberifrons* (see WG-FSA-90/16).

7.199 A conservation measure prohibiting fishing activities for finfish in Subareas 48.1 and 48.2 for the 1990/91 season was implemented (Conservation Measure 27/IX). The only reported catches for the last season are those reported from the survey carried out by Spain (WG-FSA-91/33).

Table 17: Catch by species in Subarea 48.2.

Year	<i>C. gunnari</i>	<i>N. gibberifrons</i>	<i>N. rossii</i>	Osteichthyes nei	Total
1978	138 895	75	85	2 603	141 658
1979	21 439	2 598	237	3 250 <sup>1</sup>	27 524
1980	5 231	1 398	1 722	6 217 <sup>2</sup>	14 568
1981	1 861	196	72	3 274	5 403
1982	557	589		2 211	3 357
1983	5 948	1		12 463 <sup>3</sup>	18 412
1984	4 499	9 160	714	1 583	15 956
1985	2 361	5 722	58	531	8672
1986	2 682	341		100	3 123
1987	29	3		3	35
1988	1 336	4 469			5 805
1989	532	601		1	1 134
1990	2 528	340			2 868
1991*	14	9		27 <sup>4</sup>	50

\* Catches from research activities

<sup>1</sup> Mainly *C. aceratus*

<sup>2</sup> *P. georgianus*, unidentified nototheniids and channichthyids

<sup>3</sup> Unknown species

7.200 The scarcity of historical and recent data from the commercial fishery has made any assessment of the fish stocks in the subarea difficult. Three attempts have been made so far to assess the stock of *N. gibberifrons* and *C. gunnari* using the VPA method (SC-CAMLR-VII, Annex 5; SC-CAMLR-VIII/18, WG-FSA-90/16). In addition, standing stock biomass estimates by the swept area method have been calculated from different surveys conducted in the subarea by the Federal Republic of Germany (1975/76, 1977/78, 1984/85) and Spain (1986/87, 1990/91).

#### *Champscephalus gunnari* (Subarea 48.2)

7.201 New biomass estimates for this species in the Subarea 48.2 using the swept area method were available from the Spanish survey 'ANTARTIDA 9101' (WG-FSA-91/33).

7.202 The survey design was similar to those of previous years (Balguerías, 1989) with a series of randomly located bottom trawl samples down to a depth of 500 m. The same three depth strata: 50 to 150, 150 to 250 and 250 to 500 metres were used as in previous surveys. The number of stations within each of those strata were allocated in proportion to the area of seabed and expected fish densities within the stratum.

7.203 Biomass for the whole subarea down to 500 m depth was estimated to be around 43 000 tonnes associated with a high CV of 68%. This value was obtained by extrapolating mean abundance per square nautical mile to the whole shelf area assuming that the fish were more or less equally dispersed over the shelf (WG-FSA-91/33). It is in the same order of magnitude of the size of the stock in the 1977/78 season (40 000 tonnes) (Kock, 1986). However, the Working Group noted that most of the icefish caught during the cruise was concentrated in a small area around Inaccessible Islands and its abundance could have been overestimated.

7.204 The Working Group decided that a restratification was needed, both to calculate a more realistic value of abundance and to minimise the associated CV. In doing so, two regions were considered: region A comprises a restricted area around Inaccessible Islands (Subdivisions 75 and 79 in Table 4 of SC-CAMLR-VI/BG/31), region B comprises the remaining area down to 500 m depth. Two approaches were used in calculating the standing stock biomass per stratum in region A. In the first attempt (restratification 1) all catches were used in the calculations. In the second one (restratification 2), the exceptionally high catches obtained in hauls 3 (1 038 kg/30 min) and 124 (6 137 kg/30 min) were excluded in the calculations as proposed in WG-FSA-90/13.

7.205 Details of these calculations are given in Appendix I.

7.206 The biomass estimates for the two different approaches were 9 620 tonnes (CV = 34%) and 5 606 tonnes (CV = 22%).

7.207 These values and their associated CVs are both well below those obtained in WG-FSA-91/33 (43 000 tonnes, CV = 68 %) and are likely to be more realistic. However, taking into consideration the underestimation of the areas of seabed in region A due to a lack of accuracy in the limits of the 500 m isobath in the area of seabed estimates, the minimum biomass obtained after restratification (5 606 to 9 620 tonnes) should be considered as a lower limit of stock size.

7.208 Figure 15 shows the biomass estimates for *C. gunnari* in Subarea 48.2 obtained from VPA analysis (Kock and Köster, 1989) and from different surveys carried out since 1975 (Kock, 1981; Kock, 1986; Kock *et al.*, 1985; Balguerías, 1989).

7.209 From this figure it is suggested that the size of the stock has slightly increased since 1985 (3 669 tonnes), but it is still at a very low level related to its pristine biomass in the middle of the 1970s.

### *Notothenia gibberifrons* (Subarea 48.2)

7.210 Trends of the estimated abundance of *N. gibberifrons* in Subarea 48.2 from VPA analysis (WG-FSA-90/16) and from different surveys (Kock, 1986; Kock *et al.*, 1985; Balguerías, 1990) are given in Figure 16. Previous VPA analyses were run under two assumptions of  $M$  ( $M = 0.25$  and  $M = 0.125$ ) and allocating 75 % of the catch of 'Pisces nei' reported from 1979/80 to 1982/83 to *N. gibberifrons* (WG-FSA-90/16).

7.211 Both surveys and VPA estimates (Figure 16) suggest a continuous decline of the stock from its initial size in 1976 (68 430 tonnes) up to 1987 (7 109 tonnes) with minor peaks in 1980 and 1983. The biomass estimate from the 1990/91 survey suggest that biomass has increased since then. Conservation measures introduced in the fishery (minimum mesh size of 80 mm in 1985, prohibition of directed fishing in 1989, closure of the finfish fishery in 1990) may have been responsible for the increase of the stock size in 1991.

### Other Species

7.212 The Working Group had the opportunity to assess changes in biomass of other species (*C. aceratus*, *P. georgianus*, *C. rastrospinosus*, and *N. kempfi*) based on survey estimates conducted in different years (Kock *et al.*, 1985; Kock, 1986; Balguerías, 1989; WG-FSA-91/33).

7.213 All the species considered seem to have experienced an important increase in terms of biomass after the middle of the 1980s (Figure 17). Some of them, such as *C. aceratus* and *C. rastrospinosus*, are even at a similar level to the pristine stocks, although these figures should be taken with caution because surveys may not be comparable due to different gear types, vessels etc., and also due to the variability associated with the estimates.

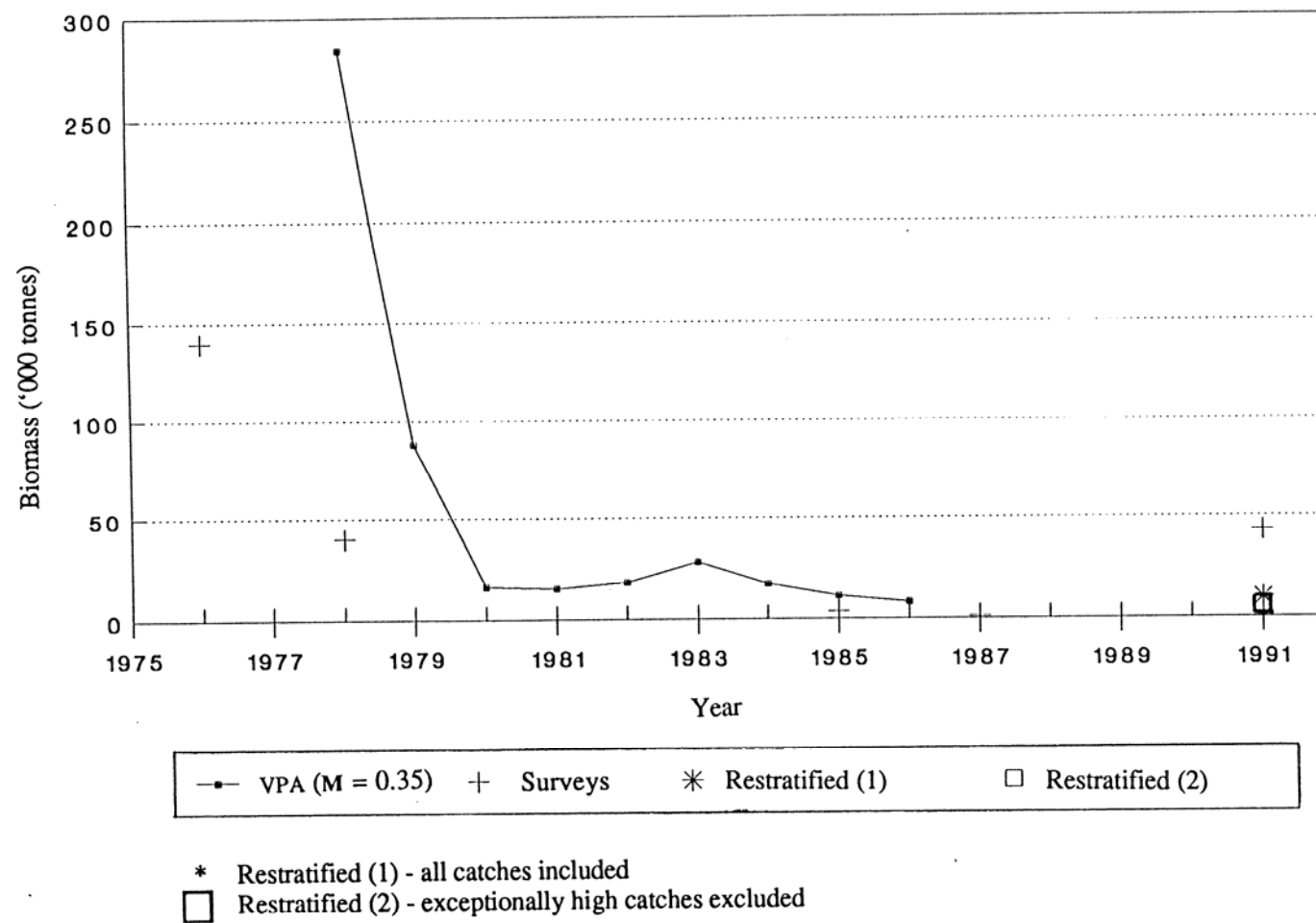


Figure 15: Biomass estimates for *C. gunnari* in Subarea 48.2.

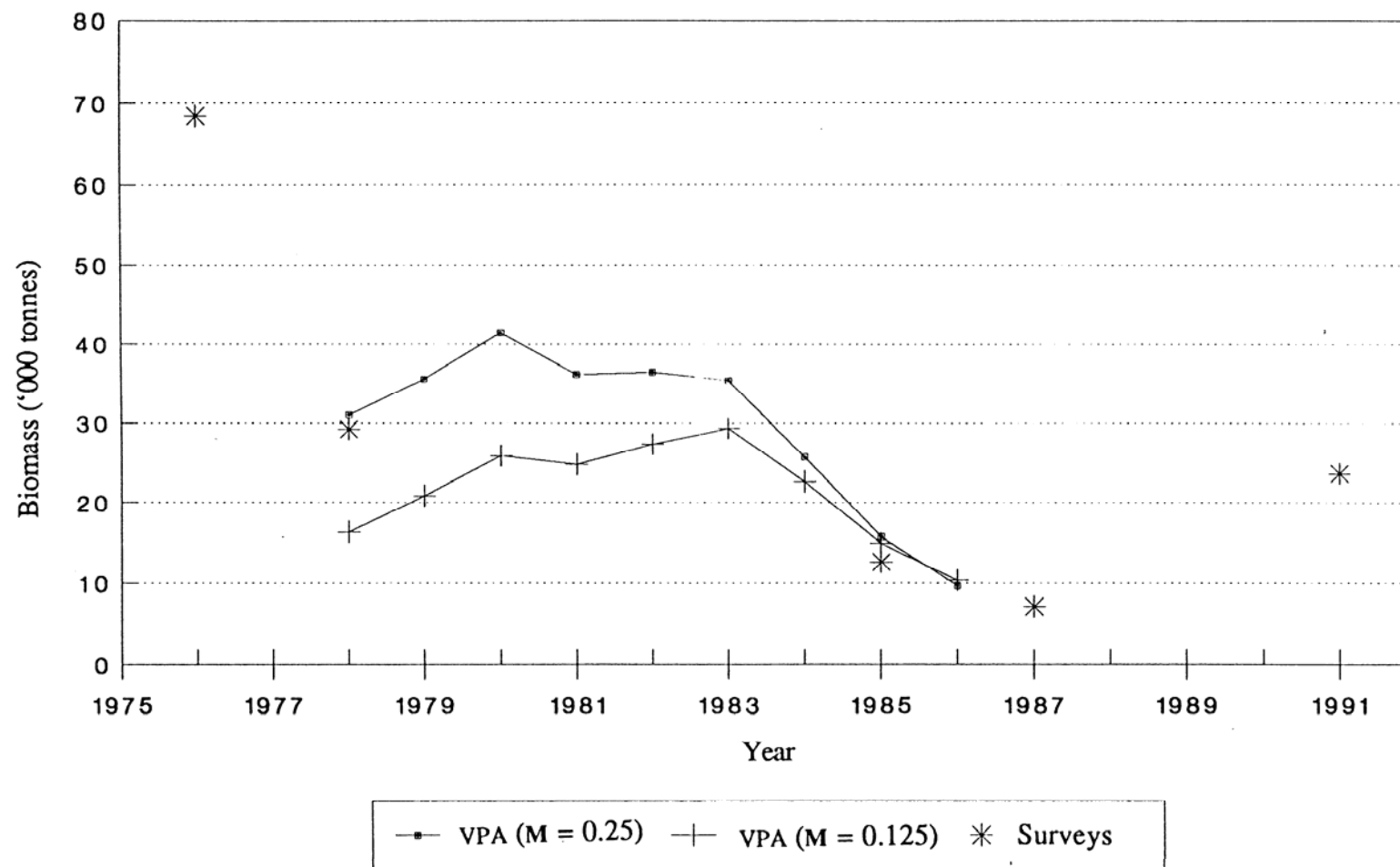


Figure 16: Biomass estimates for *N. gibberifrons* in Subarea 48.2

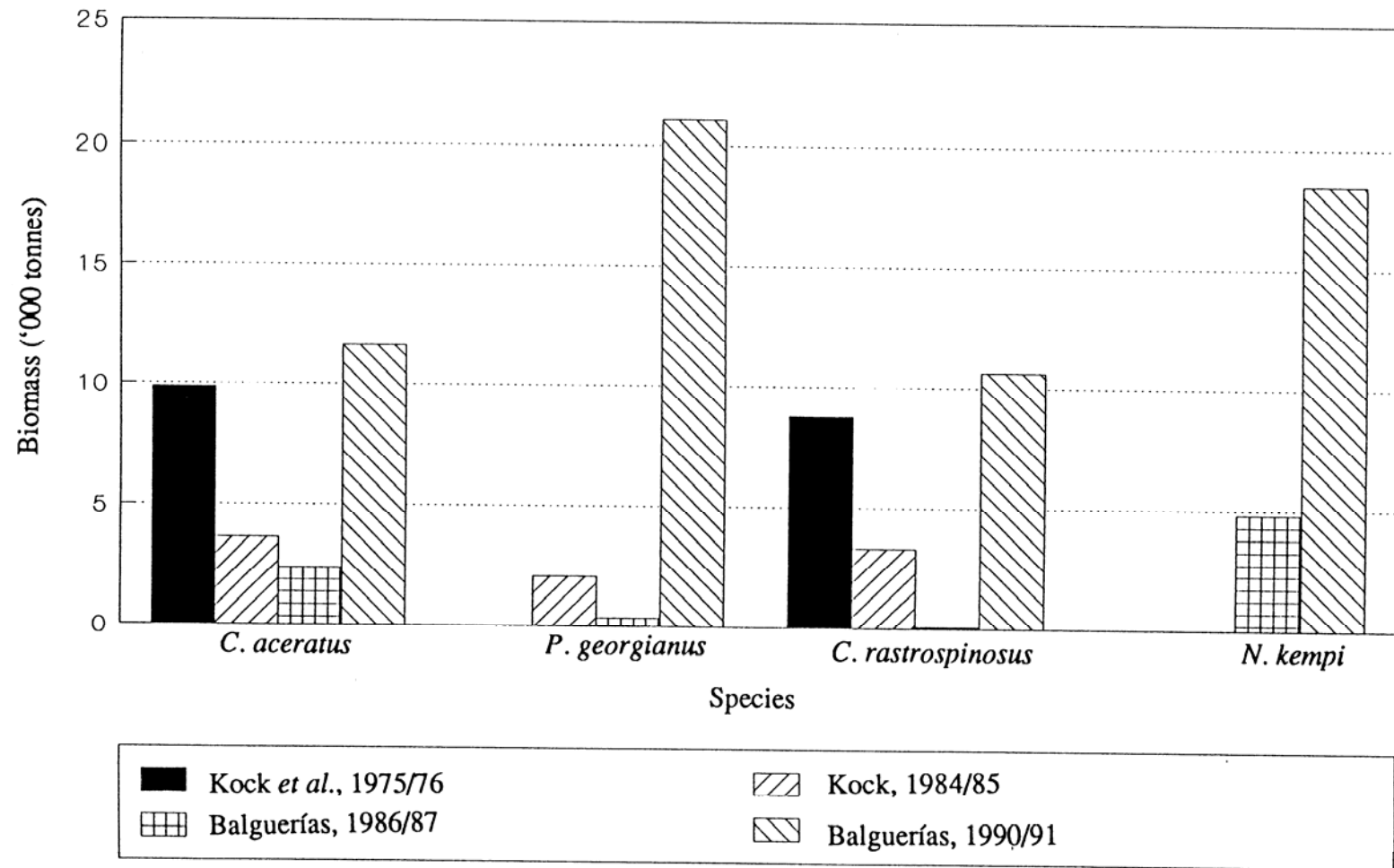


Figure 17: Survey biomass estimates for other species in Subarea 48.2.



## Calculation of TAC

7.214 MSY for the six species composing 97% of the catches taken during the Spanish survey ‘ANTARTIDA 9101’ were calculated using the Beddington-Cooke (1983) equation.

7.215 Three biomass estimates for *C. gunnari* in 1991 (before restratification and after restratification 1 and restratification 2) were considered in the calculations. **M** values are the same as those used in other analyses by the Working Group. In the absence of an **M** for *N. kempi*, the value obtained for the closely related *N. squamifrons* in Kerguelen Islands has been used.

7.216 Minimum and maximum levels of MSY corresponded to *C. gunnari*: 392 tonnes for a biomass estimate of 5 606 tonnes, and 3 010 tonnes for a biomass estimate of 42 998 tonnes. These two values were fixed as minimum and maximum TACs for this species. Trying to follow a mixed-fishery approach, the TAC for all the other species were calculated in relation to the percentage of representation of each species in the total catch of the Spanish survey ‘ANTARTIDA 9101’. That is, the expected catch of each species if any of the *C. gunnari* TACs would be attained using a bottom trawl.

7.217 The results are set out in Table 18.

Table 18: Biomass, MSY and maximum and minimum TACs for bottom trawl species in Subarea 48.2.

Species	Biomass 1991* (tonnes)	<b>M</b>	MSY Bedd.&Cook (tonnes)	% in Catch	Minimum TAC	Maximum TAC
<i>C. gunnari</i>	42 998	0.350	3 010	33	392	3 010
	9 620		673			
	5 606	0.250	1 181			
<i>N. gibberifrons</i>	23 627	0.125	591	22	261	2 007
<i>P. georgianus</i>	21 043	0.400	1 683	33	154	1 186
<i>N. kempi</i>	18 493	0.180	666	11	131	1 003
<i>C. aceratus</i>	11 603	0.300	696	11	131	1 003
<i>C. rastrispinosus</i>	10 645	0.380	809	7	83	638

\* Biomass estimates from the Spanish survey ‘ANTARTIDA 9101’

## Management Advice

7.218 Since the Commission has implemented conservation measures in Subarea 48.2 (minimum mesh size of 80 mm in 1985, prohibition of directed fishing in 1989, closure of the finfish fishery in 1990) all assessed stocks in the subarea have exhibited an upward trend in their size. However, most of them appear still far from having recovered. A possible re-opening of the fishery and its implications have been considered in light of a mixed species bottom trawl fishery (Figure 18).

7.219 The allocation of a TAC for *C. gunnari* corresponding to the maximum MSY of 3 010 tonnes (Table 18) is likely to produce catches of *N. gibberifrons*, *N. kempi*, and *C. aceratus* of respectively 1.7, 1.4 and 1.4 times in excess of their maximum MSY.

7.220 In the case of allocating TACs according to the lower MSY of *C. gunnari* (392 tonnes) the expected catches of associated species would be under their respective MSYs.

7.221 In this more conservative scenario, the estimated potential yield of a bottom trawl fishery in Subarea 48.2 would be around 1 152 tonnes.

7.222 In the absence of information about the ratios of the species in the midwater catches, the Working Group was unable to evaluate what the implications of the re-opening of such a fishery may have been.

7.223 In light of the low sustainable yield which can be obtained from a bottom trawl fishery, the still low stock size of *C. gunnari* and the uncertainties associated with the by-catch in a midwater trawl fishery on *C. gunnari* most members of the Working Group recommended that conservation measures for the subarea should be retained (Conservation Measure 27/IX).

7.224 Dr Shust suggested that a limited fishery in accordance with the calculated MSY should be allowed.

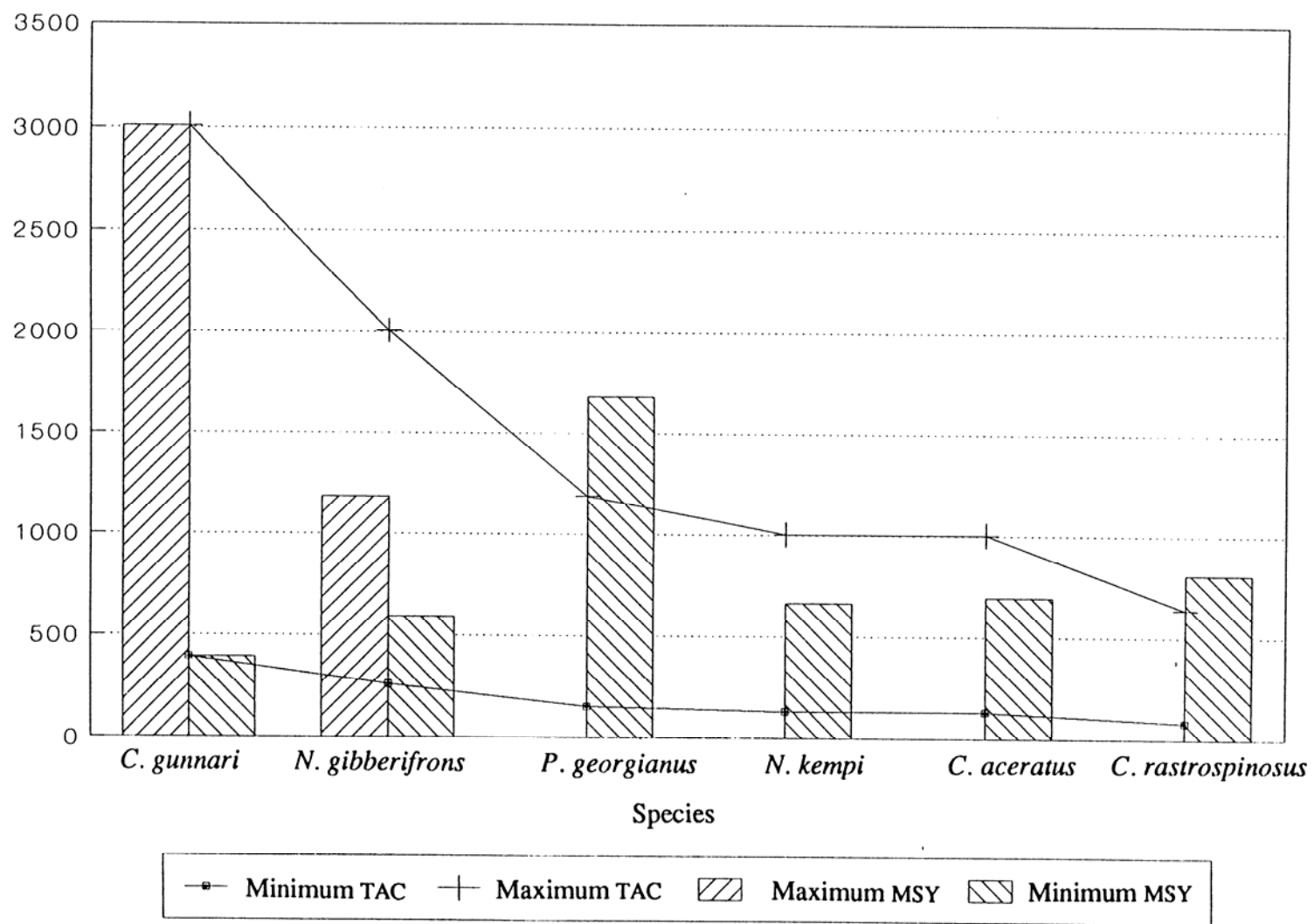


Figure 18: TAC estimates for Subarea 48.2.

## Antarctic Peninsula (Subarea 48.1)

7.225 The only new information on the fish stock abundance in this area available to the Working Group was the results of pre-recruit surveys of *N. gibberifrons*, *N. rossii* and *Notothenia neglecta*, and the analysis of the size structure of the latter two at Potter Cove (South Shetland Islands) tabled in WG-FSA-91/13. Pre-recruit abundances of *N. gibberifrons* and *N. rossii*, relative to *N. neglecta*, are at low levels compared with those found in 1983.

7.226 The size structure of the *N. rossii* population shows that during 1983 to 1986 a single cohort (year class 1980) passed through the Cove, suggesting that low abundances are the consequence of poor recruitment to the Cove. The usefulness of such a time series was pointed out and the enlargement of the number of sampling sites was recommended.

## Management Advice

7.227 In view of the very limited new information available to re-assess the state of the stocks in the Peninsula region, the Working Group recommended that the conservation measures in force for the 1990/91 season should be retained (Conservation Measure 27/IX).

## Statistical Area 58

7.228 In 1990/91 fishing took place in Subarea 58.4 and Division 58.5.1. In addition, an exploratory longline fishing cruise took place in Division 58.5.1 in the deep sea zone (> 500 m) of the Kerguelen Islands shelf. There was also a joint French/Soviet scientific cruise in the same area to investigate the *N. rossii* stock.

7.229 A summary of the catches reported from Statistical Area 58 is given in Table 19. In Division 58.5.1, the major harvested species were *C. gunnari* (80.5% of total catch), and *D. eleginoides* (11.8% of total catch). No directed fishery occurred for *N. squamifrons* or *N. rossii*.

Table 19: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champsocephalus gunnari*), LIC (*Channichthys rhinocerus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*), WIC (*Chaenodraco wilsoni*).

Split Year	ANI		LIC	WIC	TOP				NOR			NOS			ANS		MZZ			SRX
	58	58.5	58.5	58.4	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.5	58	58.4	58	58.4	58.5	58.5.1
1971	10231				XX				63636			24545					679			
1972	53857				XX				104588			52912					8195			
1973	6512				XX				20361			2368					3444			
1974	7392				XX				20906			19977					1759			
1975	47784				XX				10248			10198					575			
1976	10424				XX				6061			12200					548			
1977	10450				XX				97			308					11			
1978	72643	250	82		196	-	2	-	46155			31582		98	234		261			
1979				101	3	-	-	-				1307					1218			
1980		1631	8	14		56	138	-			1742		4370	11308			239			
1981		1122	2			16	40	-		217	7924		2926	6239			375	21		
1982		16083				83	121	-		237	9812		785	4038	50		364	7		
1983		25852				4	128	17			1829		95	1832	229		4	17	1	
1984		7127				1	145	-		50	744		203	3794				611 <sup>1</sup>	17	
1985		8253		279		8	6677	-		34	1707		27	7394	966		11	7	4	
1986		17137		757		8	459	-		-	801		61	2464	692				3	
1987		2625		1099		34	3144	-		2	482		930	1641	28		22			
1988		159		1816		4	554	488		-	21		5302	41	66					
1989		23628		306		35	1630	21			245		3660	1825	47		23	24		
1990		226		339			1062				155		1450	1262				2		
1991		13283 <sup>2</sup>					1944				287		575	98						

<sup>1</sup> Mainly *Rajiformes spp.*

<sup>2</sup> There are some discrepancies between the French statistics for the Soviet fishery under licence (12 644 tonnes) in Division 58.5.1 and the STATLANT A data provided by the USSR (13 268 tonnes). It may be explained by the inclusion of 826 tonnes of by-catch (mainly *Rajiformes*) in this total.

NB: Before 1979/80 catches reported in Statistical Area 58 mainly concern Division 58.5.1 (Kerguelen Subarea)

## Subarea 58.5

### Division 58.5.1 (Kerguelen)

7.230 Data available as a basis for assessments are from the trawl fishery for *C. gunnari* and *D. eleginoides*, longline exploratory fishing for *D. eleginoides*, and a scientific survey of the pre-spawning aggregation of *N. rossii*.

7.231 Fishing was conducted by the Soviet Union and France. The Soviet fishery, under licence from France, targetted *C. gunnari* with bottom trawls (five vessels). Fishing effort was concentrated between January and April 1991. France conducted a trawl fishery on *D. eleginoides* with one vessel in October 1990 and May 1991.

### *Notothenia rossii* (Division 58.5.1)

7.232 During fishing operations, *N. rossii* was taken only as a by-catch, and a total of 40 tonnes was reported. This is considerably less than the average for previous seasons, which was due to the *C. gunnari* fishery not occurring in the south and southeast sector, where *N. rossii* is most abundant.

7.233 The scientific cruise investigated the spawning area of this species in the south eastern part of the Kerguelen shelf during May and early June 1991. The total catch of 255 tonnes was analysed, but the data have not yet been completely assessed. These will be presented at next year's meeting of WG-FSA. The objectives of the study were not fully realised because the work was terminated before the spawning aggregation was fully formed.

7.234 Preliminary results indicate an increase in the mean length of the spawning stock compared to the last observations at a comparable time from the fishery (1984/85 season). The CPUE index of abundance from this survey indicates no significant increase in stock size since the end of the directed fishery for this species in 1984/85. In 1984/85 CPUE was 2.58 tonnes/hour, whereas in this survey it was 0.95 tonnes/hour. However, more detailed analysis of the latter figure is required because this value is derived from data acquired before the spawning aggregation was completely formed.

### Management Advice

7.235 The existing regulations in force (no directed fishery) should continue in order to protect the adult stock. Trends in the abundance of the juveniles need to continue to be monitored. Research on prespawner and spawner biomass should be continued during the 1991/92 spawning season.

#### *Notothenia squamifrons* (Division 58.5.1)

7.236 In the 1990/91 season, no directed fishery occurred on the grounds where this species is usually exploited. Only 89 tonnes were caught during the season. CPUE on the few hauls conducted on the normal fishing grounds for this species was very low, with the maximum at 0.63 tonnes/hour in January 1991. No biological data are available, and no new assessment is possible for this stock.

### Management Advice

7.237 Previous biomass estimates and VPA analyses of this stock reported to WG-FSA from 1988 to 1990 indicate that the stock size is very low. In the light of this, even a low level of catches could prevent recovery of the stocks of this species.

#### *Champscephalus gunnari* (Division 58.5.1)

7.238 The three-year cycle of the appearance of a strong cohort continued in this fishery. In 1990/91 the strong cohort of the 1988 year class entered the fishery when it reached the legal size of 25 cm total length. Its mean length observed in February 1991 was 28.4 cm TL at age 2+. The fishable part of the stock was concentrated, as usual, on the north-eastern part of the shelf, where the fishery occurred from January to April 1991. The total catch was 12 660 tonnes.

7.239 The Soviet fishing fleet (five vessels) is very homogeneous with respect to vessel and gear type and general fishing methods, so CPUE for the entire fleet can be used as an index of abundance. Mean CPUE for the 1990/91 season was 4.09 tonnes/hour fished. There was no significant decline of CPUE through the season.

7.240 It is possible to compare CPUE index of abundance of the present cohort with those of the previous exploited cohorts of 1982 and 1979 because the fishing method, area of fishing and age at exploitation were comparable. These comparisons show (Figure 19) that the present cohort at age 2 seems significantly less abundant than the 1979 and 1982 cohorts at the same age. At age 3, there has been a steady decline in abundance from the 1979 to the 1985 cohort. For the 1988 cohort, the abundance at age 3 will follow the same trend because its abundance at age 2 is already less than the abundance of 3 year old fish in previous cohorts.

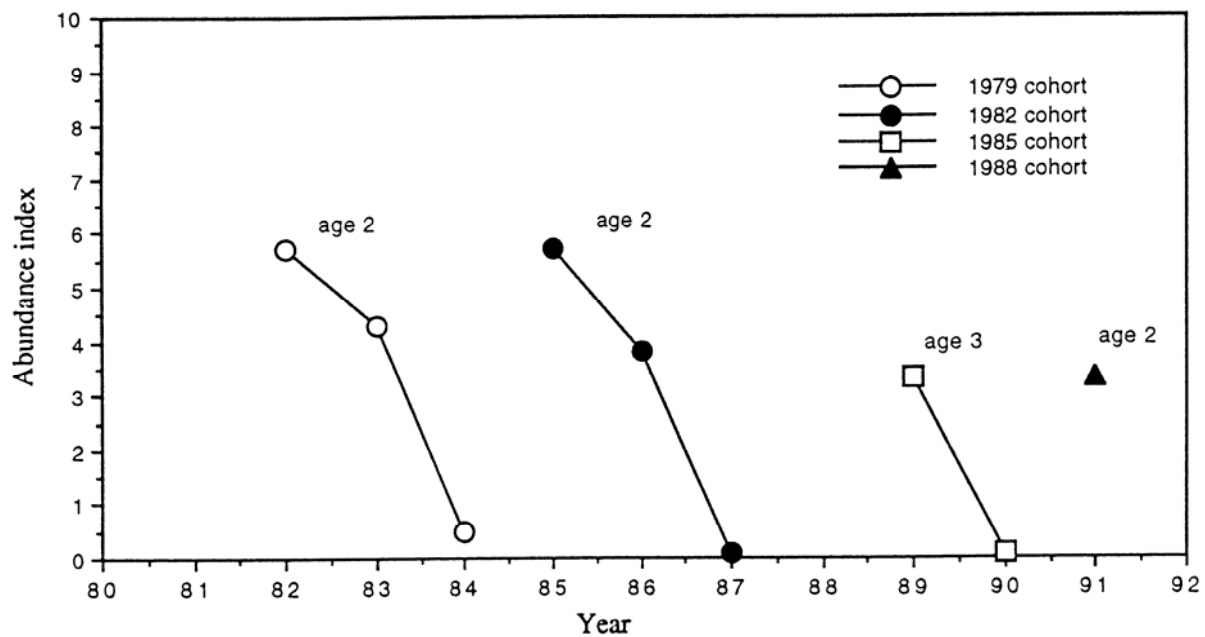


Figure 19: Abundance index of *C. gunnari* in Division 58.5.1.

7.241 The cohort analysis has been extended to include the number of fish caught in the 1990/91 season ( $100.64 \times 10^6$ ). The comparison with previous cohorts is shown in Figure 20, using the methods presented in WG-FSA-90/17. Two values of  $F$  were used to run the cohort analysis; those calculated for year class 2 of the 1979 and 1982 cohorts respectively. The value for the 1985 cohort was not used because the fishing effort was very low. The results using these  $F$  values (0.494 and 0.424) were very similar. The predicted stock size at age 3 is similar to the calculated stock sizes of the 1982 and 1985 cohorts, which produced catches of 17 055 and 23 048 tonnes at age 3 respectively.



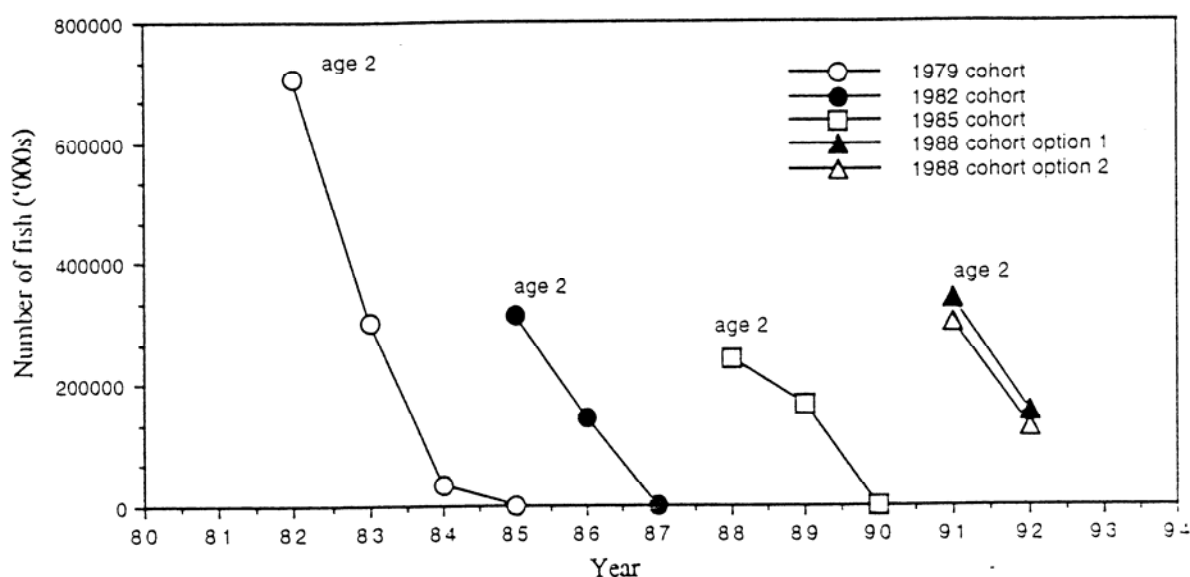


Figure 20: Population size of *C. gunnari* in Division 58.5.1.

7.242 There was no fishing on Skif Bank in the 1990/91 season. No new information can be provided on the separate stock of *C. gunnari* on this bank.

### Management Advice

7.243 Given the steady decline in index of abundance at similar ages in successive cohorts, the catch in the 1991/92 season on 3 year old fish should be less than that on previous cohorts at the same age (i.e. less than 17 000 tonnes). The cohort analysis does not indicate a significant decrease in year class strength between cohorts. This analysis, however, makes assumptions about parameters such as **F** and **M**, and so is possibly a less reliable index than CPUE, which is a direct observation from a large body of data.

7.244 The cause of disappearance of age 3 fish still needs to be resolved during the 1991/92 season.

### *Dissostichus eleginoides* (Division 58.5.1)

7.245 A total of 1 848 tonnes was caught by trawling in the 1990/91 season. This comprised 1 560 tonnes caught by France, and 288 tonnes by USSR vessels. In addition, 109 tonnes were caught in an experimental longline fishery (one Soviet longliner). The trawl fishery exploited stocks in the depth range 300 to 500 m, while the longliner fished in depths of 500 m and greater. *D. eleginoides* was the main target species for one French trawler, but a

secondary target for the Soviet trawlers, which concentrated on *C. gunnari*. At a total of nearly 2 000 tonnes this season's catch is the third highest recorded, and the third successive season in which catches have exceeded 1 000 tonnes. WG-FSA-91/9 gives a comprehensive summary of the history and characteristics of the fishery in the Kerguelen area, as requested at the 1990 meeting of WG-FSA (SC-CAMLR-IX, Annex 5, paragraph 243).

#### Western Sector

7.246 Since the first year of significant catches in 1984/85, the fishery concentrated on the western part of the shelf, and exploited sub-adults. Analysis of length frequency distribution shows a clear correlation between mean length of fish and depth fished. It is important to take this into account in the analysis of index of abundance. Three seasons in which the fishery concentrated on more shallow depths have catches with comparable length frequency distributions:

Year	Mean Length of Catch (cm)	Index of Abundance (tonnes/hour)
A. Lesser depth range		
1984/85	66.3	2.5
1986/87	69.8	1.81
1988/89	65.8	1.65

7.247 These results show a clear decline in the index of abundance. It appears that the smaller sub-adult part of the stock in the shallower part of the species' range has been affected by the fishery. During other years the fishing effort was directed to the older part of the stock in deeper water as shown by the mean length of fish caught.

Year	Mean Length of Catch (cm)	Index of Abundance (tonnes/hour)
B. Greater depth range		
1987/88	73.6	0.81
1989/90	81.6	1.26
1990/91	87.4	1.38

7.248 The index of abundance is consistently lower than in the shallower fishery, indicating a lower abundance of the larger fish, but there is no clear trend in the index as the fishery develops.

7.249 The exploratory longline fishery was also conducted in the western sector, but at greater depths than the trawl fishery. However, the length frequency distribution of the longline catch was very similar to that of the trawl fishery in the deeper waters as described above. This indicates that the longline and the deeper trawls are exploiting the same part of the stock. At this stage little more can be done to compare the two fishing methods and their relative impact on the stock.

### New Fishing Ground

7.250 The French trawl fishery exploited a new trawling ground for *D. eleginoides* during this season, which explains the relatively high total catch (1 356 tonnes in the new fishery compared to 311 tonnes for the western sector). CPUE index of abundance was 3.4 tonnes/hour which is very similar to the value obtained in the western sector in the first year of exploitation (1984/85). The length frequency distributions in the two fisheries during their first year of exploitation were also comparable.

### Management Advice

7.251 In view of the steadily declining CPUE in the western sector, the management advice in paragraph 166 of the Report of the 1989 Meeting of WG-FSA (SC-CAMLR-VIII, Annex 6) that the catch should not exceed 1 100 tonnes should be continued. If the new fishing grounds are further exploited, care must be taken that catches in these areas do not produce a decline in abundance similar to that seen in the western sector. When the new areas are further studied, the limit of 1 100 tonnes per annum may have to be revised. Considering the probably increasing importance of this species in the Kerguelen fishery, further information on age and growth and other parameters is needed for stock assessment in the future.

#### Other Species (Division 58.5.1)

7.252 A substantial by-catch in the *C. gunnari* fishery of 826 tonnes was mostly *Bathyraja spp.* A similar by catch was also observed in 1983/84 in the same area, but not in other years. No information is available for assessment of this catch.

#### Division 58.5.2 (Heard Island)

7.253 No fishery occurred in this area, and no other new data are available. No advice can be provided.

#### Subarea 58.4

##### Division 58.4.4 (Ob and Lena Banks)

7.254 The 1990 meeting of WG-FSA performed a VPA on the *N. squamifrons* stocks on these two banks, although the validity of this assessment was reduced due to the poor quality of the data. TACs of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank were set on the basis of this assessment to allow the stocks to recover from their depleted state. A combined catch of 575 tonnes for both banks was reported by USSR for the 1990/91 season, which is 100.5% of the TAC. New data were provided to the meeting too late to be analysed. These new catch data perpetuate the problem encountered at the 1990 meeting of WG-FSA, of large discrepancies between STATLANT and data submitted in assessments, and this must be resolved in good time for next year's meeting. For example, the total catch for both banks in the period 1980/81 to 1989/90 was 31 442 tonnes in the new data submitted, 33 684 tonnes in WG-FSA-90/27 and 15 439 tonnes in the Statistical Bulletin. The TACs of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank were set on the basis of VPAs using the data in WG-FSA-90/37. As these data now appear to be incorrect, and the total catches were apparently 2 500 tonnes (7%) greater over a 10-year period than assumed, it follows that the VPAs, and hence the TACs, are inaccurate.

## Management Advice

7.255 Last year's recommendation that catches should be reduced below  $F_{0.1}$  for a few years to allow the stocks to rebuild is now even more valid. A re-evaluation of the fishery on these two stocks based on definitive datasets is urgently needed. Until this is satisfactorily completed, the fishery should be closed, to avoid the danger of allowing over-fishing on the basis of inadequate information. As the present TAC is only 572 tonnes, and is probably too high, this is a real danger.

7.256 If the fishery is not closed, it is necessary that a five-day catch reporting system be instituted, as with other fisheries with TACs. Fine-scale catch and effort data should also be submitted.

### Division 58.4.2 (Coast of the Antarctic Continent)

7.257 Fine-scale catch and effort data and age/length information for *P. antarcticum* have been submitted by the USSR for the period 1978 to 1989. An analysis of these data proposed in paragraph 4.70 of the Report of the 1990 Meeting of WG-CEMP (Annex 7) was not available to the meeting, so no assessment has been made.

7.258 WG-FSA-91/4 examines the effect of oceanographic conditions on the abundance of *P. antarcticum* and *Chaenodraco wilsoni*. No other data have been provided, and so no management advice is possible.

### Other Subareas and Divisions in Statistical Area 58

7.259 No fishing was reported for Subarea 58.7 (Prince Edward and Marion Islands), Subarea 58.6 (Crozet Islands) and Divisions 58.4.3 and 58.4.1 (Coastal Areas of the Antarctic Continent).

## FUTURE WORK

### Data Requirements

8.1 Data requirements associated with specific stocks were identified by the Working Group. Appendix E lists these and other requirements identified by the Working Group.

8.2 It was noted that data requirements had been repeatedly requested by the Working Group each year. Such a list was prepared last year and once again adequate data had not been submitted and some survey reports were still being submitted in an incomplete form.

### *Dissostichus eleginoides*, Subarea 48.3

8.3 Data required by Conservation Measure 26/IX had not been reported as specified under the Conservation Measure. In particular:

- haul-by-haul data had not been reported; and
- length frequencies from the fishery had been reported for only 5 out of the 10 months of the fishery.

The requirement for reporting these data from the fishery every month should be maintained in future conservation measures.

8.4 In addition, the requirement for reporting data by five-day period should be expanded to include:

- the number of vessels;
- the coordinates of fishing activity;
- the number of hooks per set;
- the number of sets;
- the number of vessel days in the period; and
- the total number of hooks used in that period.

The latter two should be reported as a summary in the same manner as on the STATLANT B forms, and not as ranges of boats and hooks as was reported in 1990/91.

8.5 The length and age composition data used in WG-FSA-90/34 and WG-FSA-91/24 should be submitted in standard format to the Secretariat.

8.6 The Commission received an invitation in 1990 from the USSR for observers on vessels engaged in the *D. eleginoides* longline fishery. The Working Group acknowledged the advantage of having observers on these vessels for data collection, and noted that whilst no observers had been able to take up the invitation during the 1990/91 season the extension of this invitation to the 1991/92 season would be welcome.

*Electrona carlsbergi*, Statistical Area 48

8.7 At its Ninth Meeting the Commission agreed that the following information be submitted to the Secretariat (CCAMLR-IX, paragraph 4.27):

- (i) full details of the proposed fishing operation including method of fishing, mesh sizes in use, proposed target region and any indication of the minimum catch levels required to develop a viable fishery for *E. carlsbergi*;
- (ii) details of the species' stock size, abundance and demography (e.g. growth parameters and size/age at annual maturity); and
- (iii) details of the predator dependent on this resource and their requirements.

8.8 The Working Group noted that no information had been submitted in answer to requirement (i), no information additional to that submitted in 1990 (which particularly addressed stock size and demography) was available in answer to requirement (ii), and that a review paper had been prepared by the Secretariat in response to requirement (iii) (SC-CAMLR-X/BG/6). The requirements of paragraph 4.27 have therefore not been fulfilled, even though the fishery has increased by about 300%.

8.9 The following are required for *E. carlsbergi*:

- full reporting of existing biological and survey data;
- further data on the distribution, biomass, demography and age structure of *E. carlsbergi* populations both within and north of the Convention Area;

- a description of the derivation of the acoustic target strength used for surveys of *E. carlsbergi*, and the techniques used to distinguish between myctophids and krill in acoustic surveys;
- details of the by-catch in the *E. carlsbergi* fishery;
- studies on the stock identity and migration of *E. carlsbergi*, including stocks north of the South Polar Front; and
- further surveys, extending around South Georgia.

#### *Champscephalus gunnari*, Subarea 48.3

8.10 The following data are required for the *C. gunnari* fishery in Subarea 48.3:

- biological data from the commercial fishery, including representative length and age samples especially since the current 80 mm mesh will change to 90 mm mesh in the 1991/92 season (Conservation Measure 19/IX);
- quantitative information on the by-catch in the commercial midwater trawl fishery for *C. gunnari*; no additional information is available to that described in paragraph 3.42 of SC-CAMLR-IX and WG-FSA-90/15, that between 138 and 638 kg of *N. gibberifrons* and about 4 tonnes of *C. gunnari* would be caught for each haul directed at *C. gunnari*, a by-catch rate of about 3 to 15%; information on the by-catch in the demersal trawl fishery is presented in paragraphs 7.189 to 7.194 and Appendix H;
- more information is required in the reports of surveys: the position of hauls, description of cruise tracks, data on haul-by-haul catches and descriptions of methodologies used to calculate survey biomass should be given in reports of the survey in accordance with the guidelines set down in Appendix F of the Report of the 1990 Meeting of WG-FSA (SC-CAMLR-IX, Annex 5), and research data should be submitted to the Secretariat; and
- in order to resolve the discrepancies between surveys by the UK and USSR, joint cruises should be considered.



#### South Orkneys (Subarea 48.2)

8.11 Whilst the fishery in Subarea 48.2 remains closed research surveys are required every few years to investigate the status of the stocks of demersal species. Upon resumption of a commercial fishery, the collection and submission of biological data from the catch would be required.

#### Antarctic Peninsula (Subarea 48.1)

8.12 Very little biological data is available on the stocks in Subarea 48.1. A research survey is urgently required to enable assessments to be conducted.

#### Indian Ocean (Subarea 58.4)

8.13 The following are required for the Kerguelen fisheries (Division 58.4.1):

- investigations of the mortality of *C. gunnari* at age 3 to 4;
- length frequency data and age/length keys for *D. eleginoides* from both trawl and longline fisheries; and
- the abundance of *N. rossii* and *N. squamifrons* should continue to be monitored.

8.14 Fine-scale and biological data should be submitted from fisheries in Division 58.4.2 should they recommence.

8.15 The following are required from the fishery on Ob and Lena Banks (Division 58.4.4):

- correct catch data should be submitted to the Secretariat for these fisheries, given the discrepancies between data identified in paragraph 245 of last year's report (SC-CAMLR-IX, Annex 5 and paragraph 7.254 of this report);
- fine-scale data for Division 58.4.4 should be submitted to the Secretariat (paragraph 7.256); and

- age/length keys and other biological data for Subarea 58.4 should be submitted to the Secretariat.

## Research Requirements

8.16 The Working Group identified studies of age determination of *D. eleginoides* and a description of the process of longline fishing (including details of types of hooks and their deployment) as information that would significantly increase the ability of the Working Group to perform assessments of this species.

8.17 Specific information is required on the behaviour and mortality of seabirds and marine mammals in the longline and trawl fisheries and evaluations of the effectiveness of techniques for reducing this mortality should be undertaken.

8.18 One of the most important questions affecting assessments of *D. eleginoides* is whether the stock at Shag Rocks and South Georgia is effectively separate from the stocks whose distribution extends up the western coast and round the southern tip of South America (WG-FSA-91/10). Studies investigating stock identification and migration of this species are strongly encouraged, and could utilise genetic, tagging, morphometric and parasite-marker techniques.

8.19 It was pointed out that whilst tagging of adult or juvenile fish may involve a degree of increased mortality due to the tagging process, the technique may yield preliminary qualitative information about migration routes. An investigation of this type may be expensive, as in the order of 5 000 to 10 000 fish may need to be tagged. Tagging fish caught as adults or juveniles in Subarea 48.3 or off South America would be equally valuable.

8.20 Although the ability to distinguish between stocks using genetic techniques is reduced by only very little migrational exchange, these techniques are simpler to apply and could be used in an initial attempt to answer the question of stock identification in *D. eleginoides*.

8.21 An additional area of necessary research is the investigation of the existence of and patterns of migration of fish species, including *C. gunnari*, between the South Orkneys and other areas of the Scotia arc including South Georgia (see paragraphs 7.28 and 7.32).

8.22 The distribution of stocks of *E. carlsbergi* in Subarea 48.3 may be influenced by current movements on a macro-scale. Such a flux of myctophids between areas within

Subarea 48.3 and between Statistical Area 48 and areas north of the Polar Front, would have important implications for assessments and management advice. However, before considering the effects that these fluxes would have on management advice it is essential to demonstrate that they exist with respect to the *E. carlsbergi* stocks.

8.23 It is apparent that for some stocks in some areas (such as *C. gunnari* in Subarea 48.3 and Division 58.5.1) there are periodically large fluctuations in biomass and recruitment. These may be intrinsically biological in origin, or they could be related to environmental fluctuations. Studies that investigate relationships between environmental parameters and stock characteristics, such as that described in WG-FSA-91/30 which attempted to relate sea surface temperature to survey biomass, should be encouraged.

8.24 It was emphasised that whilst the functional relationships between environment and biological parameters may never be understood to a degree that enables their predictive use in management, an awareness of the qualitative relationships between these parameters may allow the Working Group to interpret assessments and stock predictions with regard to these relationships. Where advice is formulated as a range of options and probabilities, appropriate probabilities could be adjusted in the light of environmental information.

8.25 Dr Shust informed the Working Group that the USSR had many years of environmental data obtained from research cruises. He suggested that these data could be presented to the Working Group in a preliminary review by the USSR at a future meeting.

8.26 It was noted that there was no way of determining the relative reliability of the various assessment methods used in the calculation of catch levels for *D. eleginoides* (Table 8). Simulation studies investigating the robustness of the various methods that might help the Working Group to decide on their appropriateness as assessment techniques for *D. eleginoides*, would be welcome.

#### Analyses and Software to be Prepared for the Next Meeting of the Working Group

8.27 The VPA program most commonly used by the Working Group was that written by the UK Ministry of Agriculture, Fisheries and Food, Fisheries Research Laboratory. A problem encountered with this program was the inability to incorporate both CPUE and survey biomass indices with a different weighting factor for each index in the same run, and

the relatively restricted methodologies used to apply residual functions in the tuning process. The necessity of inputting weighting values by hand was also a restriction.

8.28 The Secretariat was asked to investigate updated versions of this program, and the possibility of changing the tuning modules to combine several different abundance estimates, each series of which may be incomplete. In addition, the incorporation of objective functions using maximum likelihood techniques for tuning should be considered.

8.29 Dr B. Sjöstrand (Sweden) suggested that the ADAPT program (originally written by S. Gavaris, 1988), written in APL by Dr R. Mohn (Canada), provided increased flexibility in the functions fitting VPA to tuning data and should be considered as an alternative assessment program by the Secretariat.

8.30 There are considerable uncertainties about the effects of different management strategies for *E. carlsbergi*. Strategies based on  $F_{0.1}$  were considered to be inappropriate by the Working Group (paragraph 7.144). The species is short-lived and recruits to the fishery before becoming sexually mature. It was suggested that a series of simulations should be performed to investigate the sensitivity of different management strategies to variability in recruitment and uncertainties about natural mortality, maturity and catchability.

## OTHER BUSINESS

### Closure of Fisheries Subject to a TAC

9.1 SC-CAMLR-X/BG/9 described an investigation of various methods for determining the date of closure of fisheries subject to a TAC. Two types of fisheries were investigated (constant and fluctuating catches), at different levels of catch rate, and the probability of the closure decision resulting in catches greater or less than the TAC was determined. The results indicated that the system currently in force in Conservation Measure 25/IX was the least successful method investigated, and resulted in a high probability of TAC overshoot. The most successful method operated by predicting future catch rates from the trend over a number of preceding reporting periods. The decision to close the fishery would be made when the predicted date of completion of the TAC falls within one reporting period of the date that the information on the latest catches was received by the Secretariat.

9.2 The implications of these results were that Conservation Measure 25/IX should be changed to incorporate the proposed method, and that because the overshoot probabilities

have a skewed distribution, the TAC would be more likely to be exceeded than undershot. This is primarily because of the lag time between catches being taken, their reporting to the Secretariat and the Secretariat informing Members of a closure decision, which was in the order of two to three reporting periods in the 1990/91 season.

9.3 It was suggested that to accommodate the latter point, the 'effective TAC' used for the calculations should be 95 to 98% of the agreed TAC. It was also suggested that the Secretariat be given some freedom within the conservation measure to choose the most appropriate method of determining a closure date, because SC-CAMLR-X/BG/9 showed that this often depended on the type of fishery and its catch rates.

#### Review of Working Group

9.4 The Secretariat had produced WG-FSA-91/12 in response to paragraph 311 of SC-CAMLR-IX, Annex 5. This was a useful first attempt at a review of Working Group performance, and whilst it was appreciated that such a study was very difficult, it was felt that:

- the summary of assessment results disguised many of the caveats and discussions that took place in the Working Group meetings; and
- the summary of advice from WG-FSA and action by the Commission only considered specific advice concerning management options, and did not address the many comments about data requirements and general management advice that the Working Group had provided in the past.

9.5 Despite these reservations, the review had been useful in helping the Working Group develop an overview of its work, and especially to focus attention on the ways in which assessments should be improved. It was felt that a more comprehensive internal review, periodically performed by the Convener and several other members of the group, would be most helpful in the future.

## Workshop on Survey Design and the Analysis of Research Vessel Surveys

9.6 Considerable problems associated with survey design and the application of the 'swept area' method to survey data on species that are patchily distributed were again in evidence in this year's assessments, for example those of *C. gunnari* in Subarea 48.3 (paragraphs 7.24) and Subarea 48.2 (paragraphs 7.204). The Working Group at its last meeting, drew attention to the need for investigation of these problems as a matter of priority (SC-CAMLR-IX, Annex 5, paragraph 91). Because of the specialised and detailed examination required, this work cannot be done during a regular meeting of WG-FSA. The Working Group therefore recommended that a workshop be held in the intersessional period to address the problem. Dr Kock offered to host such a workshop in Hamburg, Germany. He agreed to put a proposal forward to the Scientific Committee setting down the terms of reference of such a workshop and the costs involved.

## ADOPTION OF THE REPORT

10.1 The Report of the 1991 Meeting of the CCAMLR Working Group on Fish Stock Assessment was adopted.

## CLOSE OF THE MEETING

11.1 In closing the meeting, Dr Kock expressed his gratitude to the Members of the Working Group for their cooperation and support during the meeting and during the five years that he had been Convener. He said it was gratifying to note the improvement in the detail and the conduct of the work of WG-FSA over the period. He also thanked the Secretariat and commended its members for their dedication and efficiency.

11.2 Dr W. de la Mare (Australia), on behalf of the Working Group, thanked Dr Kock for his guidance and leadership.

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## GLOSSARY

CPUE	Catch-per-unit-effort
CV	Coefficient of variation
F	Fishing mortality
$\bar{F}_p$	Mean fishing mortality
M	Natural mortality
MSY	Maximum sustainable yield
TAC	Total allowable catch
SD	Standard Deviation
VPA	Virtual population analysis
Y/R	Yield-per-recruit



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(Hobart, Australia, 8 to 17 October 1991)

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## AGENDA

### Working Group on Fish Stock Assessment (Hobart, Australia, 8 to 17 October 1991)

1. Opening of the Meeting
2. Organization of the Meeting and Appointment of Rapporteurs
3. Adoption of the Agenda
4. The CCAMLR Scheme of International Scientific Observation
5. Approaches to Conservation
  - 5.1 New and Developing Fisheries
  - 5.2 Interaction of Other Components of the Ecosystem (e.g. birds, mammals) with Fisheries
  - 5.3 By-catch of Young and Larval Fish in the Krill Fishery
6. Review of Material for the Meeting
  - 6.1 Data Requirements Endorsed by the Commission in 1990
  - 6.2 Catch and Effort Statistics
  - 6.3 Size and Age Composition Data
  - 6.4 Other Available Biological Information
  - 6.5 Mesh/Hook Selectivity and Related Experiments Affecting Catchability
  - 6.6 Assessments Prepared by Member Countries
  - 6.7 Other Relevant Documents
7. Assessment Work and Management Advice
  - 7.1 Organization of Assessment Work
  - 7.2 Discussion of Assessments Carried Out During the Meeting and by Member Countries, and Management Advice

7.2.1 South Georgia (Subarea 48.3)

*Notothenia rossii*

*Champscephalus gunnari*

*Patagonotothen guntheri*

*Dissostichus eleginoides*

*Electrona carlsbergi*

*Notothenia gibberifrons*

*Chaenocephalus aceratus*

*Pseudochaenichthys georgianus*

*Notothenia squamifrons*

7.2.2 South Orkney Islands (Subarea 48.2)

*Champscephalus gunnari*

*Notothenia gibberifrons*

Other species

7.2.3 Antarctic Peninsula (Subarea 48.1)

*Champscephalus gunnari*

*Notothenia gibberifrons*

Other species

7.2.4 Kerguelen Islands (Division 58.5.1)

*Notothenia rossii*

*Notothenia squamifrons*

*Champscephalus gunnari*

*Dissostichus eleginoides*

7.2.5 Ob and Lena Banks (Division 58.4.4)

*Notothenia squamifrons*

Other species

7.2.6 Coastal Areas of the Antarctic Continent (Divisions 58.4.1 and 58.4.2)

*Pleuragramma antarcticum*

*Chaenodraco wilsoni*

Other species

7.2.7 Pacific Ocean Sector

8. Future Work
  - 8.1 Data Requirements
  - 8.2 Software to be Prepared or Developed Prior to the Next Meeting and Data Analyses Required
  - 8.3 Proposal for New Convener of the Working Group on Fish Stock Assessment
9. Other Business
10. Adoption of the Report
11. Close of the Meeting.

# LIST OF DOCUMENTS

## WORKING GROUP ON FISH STOCK ASSESSMENT (HOBART, AUSTRALIA, 8 TO 17 OCTOBER 1991)

WG-FSA-91/1	AGENDA FOR THE 1991 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (WG-FSA)
WG-FSA-91/2	LIST OF PARTICIPANTS
WG-FSA-91/3	LIST OF DOCUMENTS
WG-FSA-91/4	STATE OF WATER STRUCTURE AS A FACTOR DETERMINING FISH BEHAVIOUR (AT THE EXAMPLE OF KOSMONAVTOV AND SODRUZHESTVA SEAS) B.G. TROTSENKO <i>et al.</i> (USSR)
WG-FSA-91/5	ANALYSES CARRIED OUT DURING THE 1990 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT Secretariat
WG-FSA-91/6	ON THE PROBLEM OF ICEFISH ( <i>CHAMPSOCEPHALUS GUNNARI</i> ) VERTICAL MIGRATION ON THE SOUTH GEORGIA SHELF J.A. FROLKINA AND V.I. SHLIBANOV (USSR)
WG-FSA-91/7	REPRODUCTION IN THE MACKEREL ICEFISH ( <i>CHAMPSOCEPHALUS GUNNARI</i> ) AT SOUTH GEORGIA I. EVERSON <i>et al.</i>
WG-FSA-91/8	FEEDING OF NINE ANTARCTIC FISH SPECIES AND THEIR DAILY RATION EVALUATIONS Ye. A. Pakhomov and V. B. Tseitlin (USSR)
WG-FSA-91/9	BIOLOGY AND HARVESTING OF <i>DISSOSTICHUS ELEGINOIDES</i> AROUND KERGUELEN ISLAND (DIVISION 58.5.1) G. Duhamel (France)
WG-FSA-91/10	REGIONAL CATCH ANALYSIS OF THE LONGLINE FISHERY OF <i>DISSOSTICHUS ELEGINOIDES</i> (PISCES: NOTOTHENIIDAE) IN CHILE Christian Lemaitre <i>et al.</i> (Chile)

WG-FSA-91/11	HOOK SELECTIVITY IN THE LONGLINE FISHERY OF <i>DISSOSTICHUS ELEGINOIDES</i> (NOTOTHENIIDAE) OFF THE CHILEAN COAST Carlos A. Moreno (Chile)
WG-FSA-91/12	WORKING GROUP PERFORMANCE Secretariat
WG-FSA-91/13	SIZE VARIATIONS ASSOCIATED WITH ABUNDANCE CHANGES IN JUVENILE <i>NOTOTHENIA ROSSII</i> OBSERVED AT POTTER COVE, SOUTH SHETLAND ISLANDS, SINCE THE END OF THE FISHERY IN THE AREA Enrique Marschoff and Esteban Barrera-Oro (Argentina)
WG-FSA-91/14	FISH STOCK ASSESSMENT SURVEY IN SUBAREA 48.3 I. Everson <i>et al.</i>
WG-FSA-91/15	STOCK ASSESSMENT OF THE MACKEREL ICEFISH, <i>CHAMPSOCEPHALUS GUNNARI</i> (LÖNNBERG, 1906) IN SUBAREA 48.3 FOR THE 1991/91 SEASON, USING VIRTUAL POPULATION ANALYSIS G. Parkes (UK)
WG-FSA-91/16	THE UK FISH STOCK ASSESSMENT SURVEY BOTTOM TRAWL FOR SOUTH GEORGIA G. Parkes (UK)
WG-FSA-91/17	AGE/LENGTH KEY FOR <i>CHAMPSOCEPHALUS GUNNARI</i> 1990/91 FALKLANDS PROTECTOR SURVEY JANUARY/FEBRUARY 1991 UK/Poland/Germany
WG-FSA-91/18	AGE/LENGTH KEY FOR <i>CHAMPSOCEPHALUS GUNNARI</i> FROM SOUTH GEORGIA; HILL COVE SURVEY, JANUARY 1990 G. Parkes (UK)
WG-FSA-91/19	REPRESENTATIVE LENGTH AND AGE DISTRIBUTIONS FROM RANDOM STRATIFIED DEMERSAL FISH SURVEYS G. Parkes (UK)
WG-FSA-91/20	STOCK ASSESSMENT OF THE PATAGONIAN TOOTHFISH ( <i>DISSOSTICHUS ELEGINOIDES</i> ) AT SOUTH GEORGIA I. Everson (UK)
WG-FSA-91/21	A SHORT TECHNICAL CHARACTERISTIC OF BOTTOM TRAWLS USED IN SURVEYS IN THE SOUTH GEORGIA AND SHAG ROCKS AREAS IN THE 1988/89, 1989/90 AND 1990/91 SEASONS W. Moderhak and Z. Cielniaszek (Poland)



WG-FSA-91/22	<p>GENETIC POPULATION STRUCTURE OF THE MACKEREL ICEFISH, <i>CHAMPSOCEPHALUS GUNNARI</i>, IN ANTARCTIC WATERS</p> <p>G.R. Carvalho and M. Warren (UK)</p>
WG-FSA-91/23	<p>ASSESSMENT OF THE STOCKS OF ABUNDANT FISH SPECIES IN THE SOUTH GEORGIA SUBAREA (48.3) MADE ON THE BASIS OF DATA OBTAINED FROM THE RV <i>ATLANTIDA</i> TRAWL SURVEY OF APRIL/MAY 1991</p> <p>V.I. Shiblanov <i>et al.</i> (USSR)</p>
WG-FSA-91/23 Rev. 1	<p>ASSESSMENT OF THE STOCKS OF ABUNDANT FISH SPECIES IN THE SOUTH GEORGIA SUBAREA (48.3) MADE ON THE BASIS OF DATA OBTAINED FROM THE RV <i>ATLANTIDA</i> TRAWL SURVEY OF APRIL/MAY 1991</p> <p>V.I. Shiblanov <i>et al.</i> (USSR)</p>
WG-FSA-91/24	<p>ASSESSMENT OF THE <i>DISSOSTICHUS ELEGINOIDES</i> STOCK IN SUBAREA 48.3 FOR THE 1990/91 SEASON AND CALCULATION OF TAC FOR THE 1991/92 SEASON</p> <p>P.S. Gasiukov <i>et al.</i> (USSR)</p>
WG-FSA-91/25	<p>A SIMULATION STUDY OF THE METHOD OF REFINING THE NATURAL MORTALITY COEFFICIENT WITH <i>CHAMPSOCEPHALUS GUNNARI</i> IN SUBAREA 48.3 USED AS AN EXAMPLE</p> <p>P.S. Gasiukov and R.S. Dorovskikh (USSR)</p>
WG-FSA-91/26	<p>ON ASSESSING THE SIZE OF THE HUMPED ROCKCOD STOCK (<i>NOTOTHENIA GIBBERIFRONS</i>) IN SUBAREA 48.3</p> <p>P.S. Gasiukov (USSR)</p>
WG-FSA-91/27	<p>ASSESSMENT OF THE STATUS OF THE <i>CHAMPSOCEPHALUS GUNNARI</i> STOCK IN THE SOUTH GEORGIA AREA FOR THE 1990/91 SEASON AND TAC CALCULATIONS FOR THE 1991/92 SEASON</p> <p>P.S. Gasiukov (USSR)</p>
WG-FSA-91/28	<p>WITHDRAWN - SEE DOCUMENT SC-CAMLR-X/10</p>
WG-FSA-91/29	<p>FOOD AND FEEDING OF THE MACKEREL ICEFISH (<i>CHAMPSOCEPHALUS GUNNARI</i>) AROUND SOUTH GEORGIA IN JANUARY/FEBRUARY 1991</p> <p>K.-H. Kock <i>et al.</i></p>
WG-FSA-91/30	<p>TEMPERATURE AS A CAUSE OF VARIATION IN STANDING STOCK ESTIMATES OF FISH AROUND SOUTH GEORGIA</p> <p>I. Everson and S. Campbell (UK)</p>

WG-FSA-91/31	NEW AND DEVELOPING FISHERIES - COMMENTS BY WG-KRILL AND WG-CEMP Secretariat
WG-FSA-91/32	CCAMLR OBSERVATION SCHEME - COMMENTS BY WG-KRILL AND WG-CEMP Secretariat
WG-FSA-91/33	INFORME DE LA CAMPAÑA ESPAÑOLA DE EVALUACION DE LOS STOCKS DE PECES DE ORCADAS DEL SUR (‘ANTARTIDA 9101’) E. Balguerías (España)
WG-FSA-91/34	A BRIEF DESCRIPTION OF THE 1991 <i>DISSOSTICHUS ELEGINOIDES</i> FISHERY D.J. Agnew and M. Perchard (Secretariat)
WG-FSA-91/35	POTENTIAL NURSERY AREAS FOR FISH IN THE PRYDZ BAY REGION R. Williams (Australia)
WG-FSA-91/36	REPORT ON THE POLISH CATCHES AND BIOLOGICAL INVESTIGATIONS OF <i>CHAMPSOCEPHALUS GUNNARI</i> FROM COMMERCIAL CRUISE OF FV <i>LEPUS</i> IN SOUTH GEORGIA AND SHAG ROCKS AREAS DURING 1990/91 SEASON R. Zaporowski and I. Wojcik (Poland)
WG-FSA-91/37	ICHTHYOLOGICAL INVESTIGATION BY FIXED GEARS IN TERRA NOVA BAY (ROSS SEA) - SPECIES LIST AND FIRST RESULTS M. Vacchi <i>et al.</i> (Italy)

OTHER DOCUMENTS:

CCAMLR-X/6	NEW AND DEVELOPING FISHERIES Executive Secretary
CCAMLR-X/7	CCAMLR SCHEME OF INTERNATIONAL SCIENTIFIC OBSERVATION Executive Secretary
CCAMLR-X/BG/9	CHOICE OF A PROCEDURE FOR DECIDING CLOSURE OF CCAMLR FISHERIES: A SIMULATION MODEL Secretariat

SC-CAMLR-X/8	A PROPOSAL FOR THE FORMATS FOR OBSERVATIONS BY OBSERVERS ON COMMERCIAL FISHING VESSELS IN THE CCAMLR AREA Secretariat
SC-CAMLR-X/BG/2	CCAMLR DATABASES AND DATA AVAILABILITY Secretariat
SC-CAMLR-X/BG/4	INCIDENTAL CATCH OF SEABIRDS IN TRAWL FISHERIES Delegation of New Zealand
SC-CAMLR-X/BG/8	REPRODUCTIVE PERFORMANCE, RECRUITMENT AND SURVIVAL OF WANDERING ALBATROSSES <i>DIOMEDEA EXULANS</i> AT BIRD ISLAND, SOUTH GEORGIA Delegation of UK
SC-CAMLR-X/BG/12	REPRODUCTION IN ANTARCTIC NOTOTHEMIOID FISH - A REVIEW Delegation of Germany
SC-CAMLR-X/BG/13	THE STATE OF EXPLOITED FISH STOCKS IN THE SOUTHERN OCEAN - A REVIEW Delegation of Germany
SC-CAMLR-X/BG/14	INCIDENTAL MORTALITY ARISING FROM FISHERIES ACTIVITIES AROUND KERGUELEN ISLAND (DIVISION 58.5.1) Delegation of France
WG-CEMP-91/16	INTERACTIONS OF ANTARCTIC MARINE MAMMALS AND BIRDS WITH FISHERIES K.-H. Kock (Germany)
WG-KRILL-91/25	BY-CATCH OF FISH IN THE KRILL FISHERY Inigo Everson (UK), Alexei Neyelov and Yuri Permitin (USSR)

**DRAFT FORMS FOR DATA SUBMISSION**

## OBSERVER SUMMARY INFORMATION

OBSERVATION NUMBER: \_\_\_\_\_

### OBSERVER DETAILS:

Name: \_\_\_\_\_

Nationality: \_\_\_\_\_ Flag State: \_\_\_\_\_

Sponsoring Organisation: \_\_\_\_\_

Dates of Observation: from \_\_\_\_ to \_\_\_\_\_

Location of Boarding: \_\_\_\_\_

Location of Debarkation: \_\_\_\_\_

### VESSEL DETAILS:

Name of Vessel: \_\_\_\_\_

Port of Registration: \_\_\_\_\_

Call Sign: \_\_\_\_\_ Cruise Number: \_\_\_\_\_

Vessel Type: \_\_\_\_\_ Fitted Gear: \_\_\_\_\_

Size (GRT): \_\_\_\_\_ Length (LOA): \_\_\_\_\_

Area, Subarea(s) Covered: \_\_\_\_\_

On Board Acoustic Equipment: \_\_\_\_\_

Haul No. or Set No.* (HN)	Sample No.** (SN)	Date and Time of Start	Coordinates	Water Temp.	Weather	Fishing Gear	Mesh Size (if applic.)	Target Species	Bottom Depth	Fishing Depth Min-Max (m)	Duration of Fishing	Duration of Searching	Total catch (kgs)	Catch of various species (kgs)

\* A sample is not necessary for each haul or set

\*\* Haul number for trawl and set number for longline

## KRILL SAMPLE SUMMARY INFORMATION

OBSERVATION NUMBER: \_\_\_\_\_

Name of Vessel: \_\_\_\_\_ Cruise Number: \_\_\_\_\_ Area, Subarea: \_\_\_\_\_

Target Species: \_\_\_\_\_

[illegible]

(continued)

Total Size (mm)						Number of Specimens	Mean Length (mm)	Total Sample Weight (grams)	Mean Weight (grams)	Notes
25	26	27	...	61	62					

KRILL SIZE, WEIGHT, FEEDING INTENSITY AND MATURITY

OBSERVATION NUMBER: \_\_\_\_\_

HAUL NUMBER: \_\_\_\_\_

SAMPLE NUMBER: \_\_\_\_\_

Area: \_\_\_\_\_

Catch Location: \_\_\_\_\_

Date: \_\_\_\_\_

Station Number: \_\_\_\_\_

Fishing Gear Used: \_\_\_\_\_

Start Fishing: \_\_\_\_\_ End Fishing: \_\_\_\_\_

Trawling Depth (m): \_\_\_\_\_

Total Catch and Catch-per-hour Trawling: \_\_\_\_\_

Water Temperature: \_\_\_\_\_

Wind: \_\_\_\_\_ Swell: \_\_\_\_\_

Sample No.: \_\_\_\_\_

(a) Krill Number and Weight

Sample No. ....

	Length								Total
	21	22	23	24	...	...	63	64	
Juveniles (no. of specimens)									
Juveniles (weight in grams)									
Males (number)									
Males (weight in grams)									
Females (number)									
Females (weight in grams)									
Total									

(b) Krill Colouration

Sample No.: ....

Group	I-Y			II-LG			III-G			IV-DG			V-D		
Subgroup	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Juvenile (no.)															
Males (no.)															
Females (no.)															
Total															
%															

Note: (a) Liver colour - Y=yellow; LG=light green; G=green; DG=dark green; D=dark.

(b) Krill colour - A=red; B=pink; C=yellow or colourless.

FORMAT 2 (cont.)

(c) Krill Feeding Intensity

Sample No.: .....

Mean Krill Length (mm)	Sex	Section of Gastro-intestinal Tract	Degree of Stomach/Intestine Fullness (Number of krill in each category)					Mean Degree of Fullness
		Stomach	0	1	2	3	4	
		K1						
		K2						
		K3						
		K4						

(d) Individual Krill Maturity Stage Determination

Sample No.: .....

Males				
Measurement No.	Length (mm)	Maturity of Petasma	Presence of Spermatophore	General Stage of Maturity

Females					
Length (mm)	Maturity Telichum	Shape of Stern Plate	Shape of Pre-anal Spine	Thorax Condition	Presence of Spermatophore

(continued) Females

Presence of Sperm Sac	Spawn Maturity	Ovary Maturity	General Stage of Maturity	Notes



## SUMMARY OF KRILL MATURITY BY SIZE

OBSERVATION NUMBER: \_\_\_\_\_

HAUL NUMBER: \_\_\_\_\_

SAMPLE NUMBER: \_\_\_\_\_

Area, Subarea: \_\_\_\_\_

Coordinates: \_\_\_\_\_

Vessel: \_\_\_\_\_

Station: \_\_\_\_\_

Year: \_\_\_\_\_

Month: \_\_\_\_\_

Day of the Month: \_\_\_\_\_

Duration of Trawling: \_\_\_\_\_

Trawl Depth: \_\_\_\_\_

Catch: \_\_\_\_\_

[illegible]

## OBSERVATIONS OF BIRDS, MAMMALS AND BY-CATCH SPECIES

OBSERVATION NUMBER: \_\_\_\_\_

[illegible]

# LENGTH AND MATURITY OF FINFISH

OBSERVATION NUMBER: \_\_\_\_\_

HAUL NUMBER: \_\_\_\_\_

SAMPLE NUMBER: \_\_\_\_\_

SPECIES: \_\_\_\_\_

Length				Total
Male		Female		
Length	No.	Length	No.	
20				
...				
...				
65				

Maturity				Total
Male		Female		
Maturity	No.	Maturity	No.	
1				
...				
...				
6				

## AGE/LENGTH KEY AND AGE-BASED DATA FOR FINFISH

OBSERVATION NUMBER: \_\_\_\_\_

HAUL NUMBER: \_\_\_\_\_

SAMPLE NO.: \_\_\_\_\_

SPECIES: \_\_\_\_\_

[illegible][illegible]

ADDITIONAL EFFORT DETAILS FOR LONGLINE OPERATION

OBSERVATION NUMBER: \_\_\_\_\_

Set No.: \_\_\_\_\_ No. of Hooks: \_\_\_\_\_ Type of Line: \_\_\_\_\_ Length of Line: \_\_\_\_\_

Size of Hooks: \_\_\_\_\_ Spacing of Hooks (cm): \_\_\_\_\_ Type of Bait: \_\_\_\_\_

Set Times: from (h/m) \_\_\_\_ / \_\_\_\_ to \_\_\_\_ / \_\_\_\_ (h/m) \_\_\_\_ / \_\_\_\_ Hauled Times: from (h/m) \_\_\_\_ / \_\_\_\_ to (30) (h/m) \_\_\_\_ / \_\_\_\_

Height above Bottom (m): \_\_\_\_\_

### DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-90	II Data Received by WG-FSA	III Data Required by WG-FSA-91
1. <i>D. eleginoides</i> Subarea 48.3 commercial data required (length and biological) Fine-scale data required	Length data: Oct, Nov, Jan, Apr, May. No ALK 1990 Research data only Fine-scale data not reported	Length and age data from <i>D. eleginoides</i> in Subarea 48.3. Continued requirement from historical fishery
2. Data on size selectivity of longline fishery for <i>D. eleginoides</i> in Subarea 48.3	No information	Data on size selectivity of longline fishery for <i>D. eleginoides</i> in Subarea 48.3
3.		<i>D. eleginoides</i> , Subarea 48.3: <ul style="list-style-type: none"> <li>length and age data in WG-FSA- 90/34 and 91/24 should be submitted (paragraph 8.4)</li> <li>changes to 5-day reporting to include vessel days and number of hooks (paragraph 8.3)</li> </ul>
4. Report <i>E. carlsbergi</i> as <i>E. carlsbergi</i> rather than <i>Osteichthyes nei</i> Fine-scale data from Convention Area and areas north of convergence requested	No information on areas north of the convergence	Report <i>E. carlsbergi</i> catches from north of convergence (paragraph 8.9)
5. Biological data from historical catches of <i>E. carlsbergi</i> requested Fine-scale data requested	Fine-scale data not available 1989	Biological data from commercial catches (paragraph 8.9)
6.		<i>E. carlsbergi</i> , Subarea 48.3: <ul style="list-style-type: none"> <li>description of operations (CCAMLR-IX, paragraph 4.27)</li> <li>details of by-catch (paragraph 8.9)</li> <li>full reporting of existing biological and survey data (paragraph 8.9)</li> </ul>
7. Representative length-frequency from the commercial catch of <i>C. gunnari</i> in Subarea 48.3 should be reported for recent years	No information	Representative length-frequency from the commercial catch of <i>C. gunnari</i> in Subarea 48.3 should be reported for recent years (paragraph 8.9)
8.		<i>C. gunnari</i> Subarea 48.3: <ul style="list-style-type: none"> <li>quantitative information on by-catch in midwater and demersal fisheries (paragraph 8.10)</li> <li>reports from past surveys should be submitted in detail</li> <li>research data should be submitted to Secretariat (paragraph 8.10)</li> </ul>
9. Biological information on incidental catch of <i>N. rossii</i> in Subarea 48.3	No information	Biological information on incidental catch of <i>N. rossii</i> in Subarea 48.3
10. Length and age, <i>N. squamifrons</i> , Subarea 48.3 - commercial data	Research data only	Length and age, <i>N. squamifrons</i> , Subarea 48.3 - commercial data for past years (paragraph 7.17)

I	II	III
11. Commercial age and length data for <i>N. gibberifrons</i> Subarea 48.3	No data	Commercial age and length data for <i>N. gibberifrons</i>
12. <i>C. gunnari</i> and <i>N. gibberifrons</i> length and age data, Subarea 48.2 Research survey data	USSR research data on <i>N. gibberifrons</i> and <i>C. gunnari</i> length frequencies, 1989	-
13. Fine-scale catches of <i>P. antarcticum</i> , Subarea 58.4	Yes 1978 to 1989	-
14. Catches reported as <i>C. gunnari</i> from Division 58.4.2 should be <i>C. wilsoni</i>	Fine-scale data submitted and STATLANT adjusted by Secretariat	-
15. STATLANT catches of <i>N. squamifrons</i> reported from Division 58.4.4 should be corrected to agree with those in WG-FSA-90/37 Catches should be reported for Ob and Lena Banks	No information	<i>N. squamifrons</i> , Division 58.4.4 <ul style="list-style-type: none"> <li>• statlant catches should be corrected to agree with those in WG-FSA-90/37</li> <li>• catches should be reported for Ob and Lena Banks in fine-scale format (paragraph 8.15).</li> <li>• commercial age and length data should be submitted to Secretariat</li> </ul>
16. Age/length data from catches of <i>C. gunnari</i> in Division 58.5.1 prior to 1980	No data	Age/length data from catches of <i>C. gunnari</i> in Division 58.5.1 prior to 1980
17.		Commercial length and age data for the <i>D. eleginoides</i> trawl and longline fisheries in Division 58.5.1 (paragraph 8.13)
18. Various data from <i>N. squamifrons</i> in Division 58.5.1: <ul style="list-style-type: none"> <li>• length and ALK data</li> <li>• catch data separated for Division 58.5.1</li> <li>• data consistency</li> </ul>	No data	<i>N. squamifrons</i> , Division 58.5.1 <ul style="list-style-type: none"> <li>• length and ALK data</li> <li>• catch data separated for Division 58.5.1</li> <li>• data consistency</li> </ul>
19. Reports requested from <i>Slavgorod</i> , <i>Borispol</i> , <i>Passat 2</i> fishing in October 1989 (SC-CAMLR-VIII, paragraph 3.7)	No information	Reports requested from <i>Slavgorod</i> , <i>Borispol</i> , <i>Passat 2</i> fishing in October 1989 (SC-CAMLR-VIII, paragraph 3.7)
20. Want haul-by-haul information from research vessel surveys and experimental fisheries	Haul-by-haul data reported by Spain, UK, not by USSR	Want haul-by-haul information from research vessel surveys and experimental fisheries
21. An increase in availability of biological data from commercial catches (general)	Very few data from commercial catches	-
22. Information on levels of discarding and conversion rates from fish products to nominal weight are required	No information	Information on levels of discarding and conversion rates from fish products to nominal weight are required

**INPUT DATA FOR THE VPA OF *CHAMPSOCEPHALUS GUNNARI*,  
TUNED USING THE METHOD OF LAUREC-SHEPHERD TO  
SURVEY AND CPUE INDICES**

- Run 1:     **M** = 0.48  
               Ages 1 to 6+  
               Years 1976/77 to 1990/91  
               Catch-at-age as in WG-FSA-91/15 with 1990/91  
               adjusted to account for a catch of 92 tonnes (Table 3)  
               Mean weights in Table 4  
               Maturity ogive in Table 5  
               Tuned to abundance indices in Table 6  
               Regression weighted according to inverse CV
- Run 2:     **M** = 0.48  
               Ages 1 to 6+  
               Years 1976/77 to 1989/90  
               Catch-at-age as in WG-FSA-91/15 with 1990/91  
               adjusted to account for a catch of 92 tonnes (Table 3)  
               Mean weights in Table 4  
               Maturity ogive in Table 5  
               Tuned to CPUE indices in table 7  
               Regression weighted according to inverse CV

Table 1: Commercial catch-at-age, *C. gunnari*, South Georgia 1976/77 to 1990/91. Numbers of fish x 10<sup>3</sup> (WG-FSA-91/15).

Year	Age					
	1	2	3	4	5	6
1977	1	350	173 132	201 466	32 269	3 844
1978	2 899	59 909	4 866	3 528	1 082	593
1979	88	5 258	614	232	49	33
1980	1	39 008	14 350	4 930	903	573
1981	2 200	261 434	30 901	5 197	1 248	831
1982	12 716	264 956	53 952	33 271	7 766	5 666
1983	43 877	743 217	191 146	72 835	18 850	13 378
1984	9 853	702 144	881 88	23 282	1 176	155
1985	1 335	89 878	31 631	4 280	185	271
1986	3 849	83 462	12 127	6 738	712	115
1987	6 920	207 120	276 940	19 310	4 210	700
1988	8 600	12 420	70 060	35 510	25 160	6 850
1989	10 250	128 890	14 470	9 180	11 490	2 310
1990	240	6 195	31 920	1 967	96	1
1991	2	215	242	86	4	2



Table 2: Mean weight-at-age (kg) for the stock and in the catch for all years, 1976/77 to 1990/91 (Anon., 1990a).

Age:	1	2	3	4	5	6
Mean weight (kg)	0.029	0.083	0.169	0.284	0.421	0.575

Table 3: Maturity ogive for all years 1976/77 to 1990/91 (Anon., 1990a).

Age:	1	2	3	4	5	6
Proportion mature	0	0.5	0.65	0.75	0.75	0.75

Table 4: Standardised survey abundance indices, number of fish x 10<sup>3</sup>, 1986/87 to 1990/91 for **M** = 0.48.

Year*	Effort	Age					
		1	2	3	4	5	6+
1987	100	21 325	382 233	255 150	21 466	2 796	410
1988	100	32 083	39 700	115 735	30 436	17 586	4 862
1989	100	474 160	213 813	53 045	29 936	15 235	3 355
1990	100	114 350	880 914	200 336	12 681	928	2 061
1991	100	241 636	68 550	53 919	22 595	1 324	437

\* References:

1986/87 SC-CAMLR-VI/BG/12 Rev. 1  
1987/88 SC-CAMLR-VII/BG/23  
1988/89 WG-FSA-89/6  
1989/90 WG-FSA-90/11 Rev. 1  
1990/91 WG-FSA-91/14

Table 5: Standardised effort indices and catch at age for *C. gunnari* in Subarea 48.3 (effort from WG-FSA-90/27).

Year	Effort	Age					
		1	2	3	4	5	6+
1981	14 142	2 200	261 434	30 901	5 197	1 248	31
1982	7 182	12 716	264 956	53 952	33 271	7 766	5 666
1983	20 420	43 877	743 217	191 146	72 835	18 850	13 378
1984	15 798	9 853	702 144	88 188	23 282	1 176	155
1985	2 984	1 335	89 878	31 631	4 280	185	271
1986	4 483	3 849	83 462	12 127	6 738	712	115
1987	20 035	6 920	207 120	27 6940	19 310	4 210	700
1988	15 941	8 600	124 20	70 060	35 510	25 160	6 850
1989	7 972	10 250	128 890	14 470	9 180	11 490	2 310
1990	1 497	217	5 610	28 902	1 781	87	1

**DELURY METHOD OF CALCULATING INITIAL STOCK SIZE  
OF *DISSOSTICHUS ELEGINOIDES* FROM A CPUE SERIES**

The Chapman formulation of the deLury analysis was applied to *D. eleginoides* in Subarea 48.3 by considering population growth by month and assuming that initially the population existed under conditions of replacement recruitment.

Replacement recruitment  $R = N_1(1-e^{-m})$

where  $N_1$  = initial population size  
 $m$  = monthly natural mortality =  $M/12$

Numbers at month 1,2,3...t are

$$\begin{aligned}
 N_1 & \\
 N_2 &= N_1 e^{-m} + R - C_1 \\
 &= N_1 e^{-m} + N_1(1-e^{-m}) - C_1 \\
 N_3 &= N_2 e^{-m} + N_1(1-e^{-m}) - C_2 \\
 &= [N_1 e^{-m} + N_1(1-e^{-m}) - C_1] e^{-m} + N_1(1-e^{-m}) - C_2 \\
 &= N_1 [e^{-2m} + (1-e^{-m})e^{-m} + (1-e^{-m})] - C_1 e^{-m} - C_2 \\
 &= N_1 - C_1 e^{-m} - C_2
 \end{aligned}$$

If  $D$  is defined such that

$$D_{t+1} = D_t e^{-m} + C_t \quad \text{then}$$

$$N_t = N_1 - D_t \tag{1}$$

Now Catch =  $N \cdot q \cdot \text{Effort}$  and therefore  $C/E = \text{CPUE} = N \cdot q$

Multiplying (1) by  $q$

$$qN_t = \text{CPUE}_t = qN_1 - qD_t \tag{2}$$

therefore a regression of  $D$  against CPUE will have intercept  $qN_1$ , and slope  $q$ , enabling initial population size to be calculated by

$$N_1 = \text{intercept/slope}$$

These calculations were performed for populations starting in July 1989 and July 1990, yielding the results in Table 7 of this report.

**CALCULATIONS FOR ASSESSMENT OF TOTAL DEMERSAL CATCH,  
SUBAREA 48.3 (AGNEW AND KOCK)**

1. Catch from Subarea 48.3 by Poland by bottom trawl:

	Total	SSI	SGI	NOG	NOS	ANI	TOP	SRX
1980	11 692	1 084	665	7 274		753	255	218
1981	17 656	1 272	1 661	4 949		9 166	71	74
1982	8 324	676	956	970		4 446		1
1985	5 709	1 042	1 097	1 583		389	88	16
1986	3 926	504	156	463		2 506	29	16
1987	1 952	221	72	211	26	1 397		
1988	1 630	198	319	202	112	784	15	
1989	8				4			

Calculated ratios of: SSI/SGI/NOG/ANI

1980	1/0.613/6.7/0.695
1981	1/1.31/3.89/7.21
1982	1/1.41/1.44/6.57
1985	1/1.05/1.52/0.373
1986	1/0.31/0.92/4.97
1987	1/0.33/0.96/6.32
1988	1/1.61/1.02/3.96

For NOG, 1980 and 1981 were years of high but declining stock size. For ANI, 1980 and 1985 were abnormally low ratios. These years have been left out of the following calculations.

Mean ratios taken over 1980 to 1988 for SSI, SGI; 1982 to 1988 for NOG; 1981, 1982 and 1986 to 1988 for ANI.

1/0.947/1.17/5.8

2. Calculations of MSY using Table 2 of Beddington and Cooke (1983):

	NOG	SSI	SGI
TOTAL UNEXPLOITED BIomass	42 000 <sup>1</sup>	18 000 <sup>1</sup>	44 000 <sup>2</sup>
Age of recruitment	4 <sup>1</sup>	6 <sup>1</sup>	3 <sup>2</sup>
<b>K</b>	0.15 <sup>3</sup>	0.20 - 0.30 <sup>2</sup>	0.527 <sup>2</sup>
<b>M</b>	0.125 <sup>1</sup>	0.3 <sup>2</sup>	0.4 <sup>2</sup>
$\lambda^4$	0.035	0.118 - 0.127	0.18
MSY (biomass x $\lambda$ )	1 470	2 124 - 2 286	7 920

Values from WG-FSA-91/5, 90/6, Kock *et al.* 1985

<sup>1</sup> WG-FSA-91/5

<sup>2</sup> WG-FSA-90/6

<sup>3</sup> Kock *et al.*, 1985

<sup>4</sup> Table 2 of Beddington and Cooke, 1983

SSI *C. aceratus*

SGI *P. GEORGIANUS*

NOG *N. gibberifrons*

NOS *N. squamifrons*

ANI *C. GUNNARI*

TOP *D. elegendoides*

SRX Rajiformes spp.

**DETAILS OF CALCULATIONS OF BIOMASS ESTIMATES FROM THE  
RESEARCH CRUISE ‘ANTARTIDA 9101’ IN SUBAREA 48.2**

Depth (m)	Subarea 48.2	<i>Champsoccephalus gunnari</i>				
		Region A <sup>1</sup>		Region B <sup>2</sup>	Total	
		All Catches	High Catches Excluded		All Catches	High Catches Excluded
50-150	Nº hauls	9		12	21	21
	X (kg/0.021 nm <sup>2</sup> )	1.864		3.107	2.493	2.493
	SD	1.270		1.635	1.038	1.038
	CV (%)	68		53	42	42
	DM (t/nm <sup>2</sup> )	0.089		0.148	0.119	0.119
	BME (t)	38		65	104	104
	Extension (nm <sup>2</sup> )	431		441	872	872
150-250	Nº hauls	17	16	24	41	40
	X (kg/0.021 nm <sup>2</sup> )	118.119	60.605	2.248	52.696	27.655
	SD	61.323	22.649	0.482	26.700	9.865
	CV (%)	52	37	21	51	36
	DM (t/nm <sup>2</sup> )	5.625	2.886	0.107	2.509	1.317
	BME (t)	2672	1371	66	2738	1437
	Extension (nm <sup>2</sup> )	475	475	616	1091	1091
250-500	Nº hauls	14	13	52	66	65
	X (kg/0.021 nm <sup>2</sup> )	566.420	137.996	10.392	21.627	12.970
	SD	432.669	65.316	3.405	9.358	3.588
	CV (%)	76	47	33	43	28
	DM (t/nm <sup>2</sup> )	26.972	6.571	0.495	1.030	0.618
	BME (t)	3587	874	3191	6799	4065
	Extension (nm <sup>2</sup> )	133	133	6494	6582	6582
Total (50-500)	Nº hauls	40	38	88	128	126
	X (kg/0.021 nm <sup>2</sup> )	127.280	46.145	9.296	23.642	13.776
	SD	62.078	13.319	2.927	7.974	3.039
	CV (%)	49	29	31	34	22
	DM (t/nm <sup>2</sup> )	6.061	2.197	0.443	1.126	0.656
	BME (t)	6297	2283	3323	9620	5606
	Extension (nm <sup>2</sup> )	1039	1039	7506	8545	8545

<sup>1</sup> 60°20'S - 61°00'S (see figure in this appendix)  
46°00'W - 47°00'W

<sup>2</sup> Remaining area (see figure in this appendix)

X Mean biomass in 0.021 nm<sup>2</sup> (corresponding to a 30 minute haul)

SD Standard deviation of the mean

CV Coefficient of variation

DM Mean density

BME Mean trawlable biomass

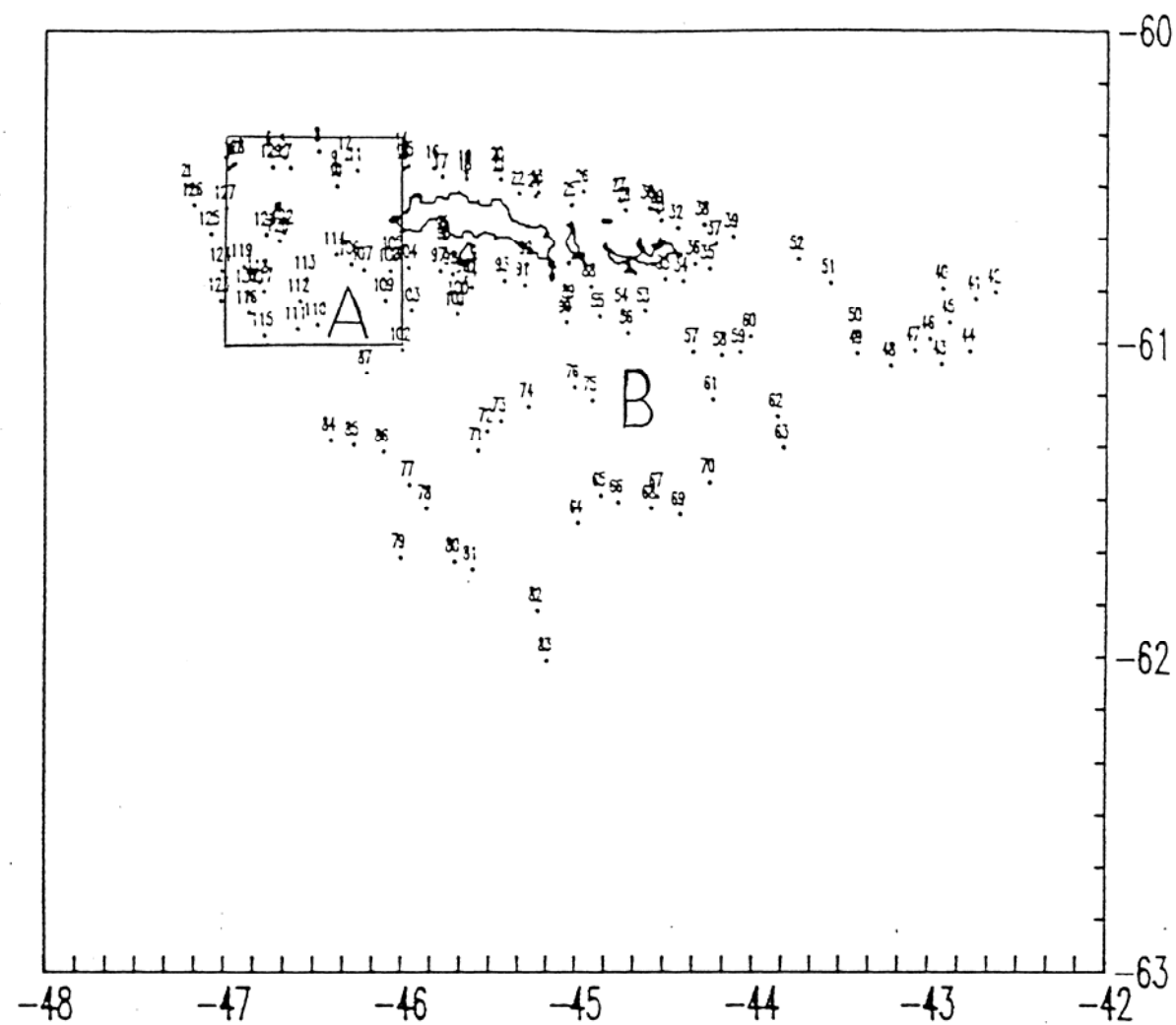


Figure I.1: Location of hauls - 'ANTARTIDA 9101'.

**1991 ASSESSMENT SUMMARIES**

Assessment Summary: *Notothenia rossii*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC					0			
Agreed TAC					300	300		
Landings	70	216	197	152	2	1	24897	1
Survey Biomass		11471 <sup>a</sup> 1634 <sup>b</sup>	1699	2439	1481 <sup>a</sup> 3915 <sup>b</sup> 3900 <sup>b</sup>	4295 <sup>c</sup> 10022 <sup>d</sup>		
Surveyed by		Spain <sup>a</sup> USA/POL <sup>b</sup>	USA/POL	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>c</sup> USSR <sup>d</sup>		
Sp. Stock Biomass <sup>3</sup>			No information available since 1985/86					
Recruitment (age...)								
Mean F (.....) <sup>1</sup>								

Weights in tonnes, recruits in .....

1 ...weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (.....)

**Conservation Measures in Force:** 2/III, 3/IV, 20/IX

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Although survey biomass estimates indicate slightly higher stock than previous years, the stock is still at a very low level.

**Forecast for 1991/92:**

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Champscephalus gunnari*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC			31500	10200	12000			
Agreed TAC			35000	- <sup>4</sup>	8000	26000		
Landings	11107	71151	34619	21359	8027	92	128194 <sup>6</sup>	7592
Survey Biomass		159283	15716	22328 <sup>5</sup>	149598 <sup>a</sup>	26204 <sup>a</sup>		
					442168 <sup>b</sup>	192144 <sup>b</sup>		
Surveyed by		Spain	USA/POL	UK/POL	UK/POL <sup>a</sup>	UK <sup>a</sup>		
					USSR <sup>b</sup>	USSR <sup>b</sup>		
Sp. Stock Biomass <sup>3</sup>								
Recruitment (age...)								
Mean F (.....) <sup>1</sup>								

Weights in tonnes

- |   |                                   |   |                                   |
|---|-----------------------------------|---|-----------------------------------|
| 1 | ... weighted mean over ages (...) | 4 | Prohibition from 4 November 1988  |
| 2 | Over period 1981 to 1991          | 5 | Standard estimate from Appendix D |
| 3 | From VPA using (.....)            | 6 | Maximum catch in 1983             |

**Conservation Measures in Force:** 19/IX, 20/IX, 21/IX, 25/IX

**Catches:**

Poland	41 tonnes (commercial)
UK	3 tonnes (research)
USSR	49 tonnes (research)

**Data and Assessment:** Commercial length data in WG-FSA-91/36. VPA assessments tuned to commercial effort and survey abundance indices in WG-FSA-91/27 and WG-FSA-91/15.

**Fishing Mortality:** Very low F in 1990/91.

**Recruitment:** Uncertainty regarding current strength of 1987/88 year class. Survey reported in WG-FSA-91/14 shows high proportion of 1 year olds. Subject to significant uncertainty, indications of a large decline since 1989/90.

**State of Stock:**

**Forecast for 1991/92:**

Option Basis	F	1991 Stock	Catch	F	1992 Stock	Catch	Implications/Consequences
CPUE tuned F <sub>0.1</sub> M = 0.48				0.39	236779	61870	Could lead to serious over-exploitation if stock status is accurately assessed by survey tuned VPA
Survey tuned F <sub>0.1</sub> M = 0.48				0.39	41834	9672	

Weights in '000 tonnes



Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC				-	-	20-36000		
Agreed TAC				13000	12000	0		
Landings	16002	8810	13424	13016	145	0	36788 <sup>4</sup>	5029
Survey Biomass		81000				584 <sup>a</sup>		
Surveyed by		Spain				16365 <sup>b</sup>		
						UK <sup>a</sup>		
						USSR <sup>b</sup>		
Sp. Stock Biomass <sup>3</sup>					na			
Recruitment (age 1)					na			
Mean F (3 - 5) <sup>1</sup>					na			

Weights in tonnes

- 1 ... weighted mean over ages (...)
- 2 Over period 1981 to 1991
- 3 From VPA using (.....)
- 4 Maximum catch in 1989

**Conservation Measures in Force:** 23/IX

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Unknown

**Forecast for 1991/92:**

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC					-			
Agreed TAC					-	2500 <sup>5</sup>		
Landings	564	1199	1809	4138	8311	3843	8311	109
Survey Biomass		1208	674	326	9631 <sup>*a</sup> 1693 <sup>*b</sup>	335 <sup>+a</sup> 3020 <sup>+b</sup>		
Surveyed by		USA/POL <sup>4</sup>	USA/POL <sup>4</sup>	UK/POL <sup>4</sup>	POL/UK <sup>a</sup> USSR <sup>b</sup>			
Stock Biomass <sup>3</sup>					20745 - 435817			
Recruitment (age...)					na			
Mean F (.....) <sup>1</sup>					na			

Weights in tonnes

1 ... weighted mean over ages (...) 5 TAC from 1 November 1990 to 2 November 1991

2 Over period 1981 to 1991 \* Shag Rocks

3 Estimated from cohort projections + South Georgia

4 Survey excluding Shag Rocks

**Conservation Measures in Force:** 24/IX, 26/IX

**Catches:** Before TAC 1 440 and under TAC 2 394 = 3 834 tonnes.

**Data and Assessment:** Two assessments presented by members (WG-FSA-91/20 and 24). Both methods subject to criticism. No haul-by-haul data. STATLANT B data and some length frequency data.

**Fishing Mortality:** Insufficient information.

**Recruitment:** WG-FSA-91/20 suggest large number of 2 year olds in 1989/90 but very low number of 3 year olds in 1990/91 (bottom trawl survey).

**State of Stock:** Very uncertain (range about 14 000 - 609 000). CPUE suggests stock is NOT increasing.

**Forecast for 1991/92:** Suggested catch levels range 400 to 11 000 tonnes.

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC								
Agreed TAC								
LANDINGS	1678	2844	5222	838	11	3	11758	0
SURVEY BIOMASS	0	1400	7800	8500	17000	25000		
SURVEYED BY		USA	USA	UK	UK USSR	UK USSR		
Sp. Stock Biomass <sup>3</sup>	4200	4700	4300	3300	4300	6200	18800	3300
Recruitment (age 2)	25000	24000	24000	21000	27000	25000	27000	13000
Mean F (.....) <sup>1</sup>	0.19	0.36	0.86	0.54	0.014	0.0002	0.95	0.0

Weights in tonnes

<sup>1</sup> Weighted mean over ages 2 to 16

<sup>2</sup> Over period 1975/76 to 1990/91

<sup>3</sup> From VPA using survey q = 1 model

**Conservation Measures in Force:** 22/IX

**Catches:** Low in recent years due to low fishing effort.

**Data and Assessment:** VPA analysis tuned to survey biomass estimates treated as measures of absolute biomass.

**Fishing Mortality:** Low in recent years due to low fishing effort.

**Recruitment:** Stable.

**State of Stock:** Increasing. Current biomass roughly one half of virgin level.

**Forecast for 1991/92:**

Option Basis	F	1992 SSB	Catch	F	1993 SSB	Catch	Implications/ Consequences
<b>F</b> <sub>0.1</sub> , survey q = 1 model	<b>F</b> <sub>0.1</sub> = 0.0935	7700	1400	<b>F</b> <sub>0.1</sub> = 0.0935	9300	1600	conservative option
<b>F</b> <sub>0.1</sub> , survey q $\square$ 1 model	<b>F</b> <sub>0.1</sub> = 0.0935	9000	5000	<b>F</b> <sub>0.1</sub> = 0.0935	20000	8000	riskier option

Weights in tonnes

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC				1100	0	300		
Agreed TAC				0	300	300		
Landings	504	339	313	1	2	2	1272	1
Survey Biomass		8621	6209	5770	14226 <sup>a</sup> 14424 <sup>b</sup> 17800 <sup>b</sup>	13474 <sup>c</sup> 18022 <sup>d</sup>		
Surveyed by		USA/POL	USA/POL	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>	UK <sup>c</sup> USSR <sup>d</sup>		
Sp. Stock Biomass <sup>3</sup>	3006	4179	4156	4404	5098 <sup>4</sup>			
Recruitment (age 2)	6573	5375	8648	6717	4047 <sup>4</sup>			
Mean F (.....) <sup>1</sup>	0.19	0.17	0.13	0.002				

Weights in tonnes, recruits in '000s

- 1 ... weighted mean over ages 3 to 11
- 2 Over period 1981 to 1991
- 3 From VPA using revised VPA from WG-FSA-90/6
- 4 Predicted

**Conservation Measures in Force:** 20/IX, 22/IX

**Catches:** The only catches in 1990 and 1991 were research catches since the fishery was closed by Conservation Measure 22/IX.

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Current stock size is increasing slowly and has recovered to 80 to 90% of its initial level.

**Forecast for 1991/92:**

Option Basis	F	1991 Biomass	Catch	F	1992 SSB	Catch	Implications/ Consequences
F <sub>0.1</sub>					1300-1800	1757 <sup>1</sup>	

Weights in tonnes

- 1 Adjusting the value calculated by WG-FSA-90 by a factor of 1.1 as a consequence of the difference in biomass estimates.

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC				1800	0	300		
Agreed TAC					300	300		
LANDINGS	156	120	401	1	1	2	1661	1
SURVEY BIOMASS		5520	9461	8278	5761 <sup>A</sup> 12200 <sup>B</sup> 10500 <sup>B</sup>	13948 <sup>C</sup> 9959 <sup>D</sup>		
SURVEYED BY		USA/POL	USA/POL	UK/POL	UK/POL <sup>A</sup> USSR <sup>b</sup>	UK <sup>C</sup> USSR <sup>d</sup>		
Sp. Stock Biomass <sup>3</sup>	3758	5498	8090	8889 <sup>4</sup>				
Recruitment (age 1)	1819	4337	1372					
	7							
Mean F (.....) <sup>1</sup>	0.08	0.09	0.15					

Weights in tonnes, recruits in '000s

- 1 ... weighted mean over ages 3 to 6
- 2 Over period 1981 to 1991
- 3 From VPA described in WG-FSA-90/6
- 4 Predicted

**Conservation Measures in Force:** 20/IX, 22/IX

**Catches:** The only catches since 1989 have been research catches.

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** The stock has increased slowly over the last few years and is now about 30% of its initial level.

**Forecast for 1991/92:**

Option Basis	F	1992 SSB	Catch <sup>1</sup>	Implications/ Consequences
<b>F = F<sub>0.1</sub></b>		10000-14000	4756	
<b>F = 50% F<sub>0.1</sub></b>		10000-14000	2717	

Weights in tonnes

- 1 Adjusting the value calculated by WG-FSA-90 by a factor of 1.33 as a consequence of the difference in biomass estimate.

Assessment Summary: *Notothenia squamifrons*, Subarea 48.3

**Source of Information:**

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sub>2</sub>
Recommended TAC					0	300			
Agreed TAC					300	300			
Landings	41	190	1553	927	0	0	1553	0	563
Survey Biomass		13950	409	131	1359 <sup>a</sup> 534 <sup>b</sup>				
Surveyed by		USA/POL	USA/POL	UK/POL	UK/POL <sup>a</sup> USSR <sup>b</sup>				
Sp. Stock Biomass <sup>3</sup> Recruitment (age...) Mean <b>F</b> (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (.....)

**Conservation Measures in Force:** 20/IX, 22/IX

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** No new information on this stock is available.

**Forecast for 1991/92:**

Option Basis	<b>F</b>	1991 SSB	Catch	<b>F</b>	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

**Source of Information:**

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	M-in <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC	-	-	-	-	-	-	-	-	-
Agreed TAC	-	-	-	-	-	-	-	-	-
Landings	1187	1102	14868	29673	23623	78488			
Survey Biomass			1200 kt	USSR <sup>4</sup>					
Surveyed by			160 kt	USSR <sup>5</sup>					
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)
- 2 Over period 1981 to 1991
- 3 From VPA using (.....)
- 4 WG-FSA-90/21 large portion of Subarea 48.3
- 5 WG-FSA-90/21 Shag Rocks region

**Conservation Measures in Force:** Nil (But see CCAMLR-IX, paragraph 4.27).

**Catches:** Threefold increase in catch from 1989/90 to 1990/91. Fishery takes mostly juvenile fish (2 year olds).

**Data and Assessment:** WG-FSA-90/21 and 23 for biomass yield-per-recruit analysis.

**Fishing Mortality:** 0.64 (to give around 50% escapement to spawning stock).

**Recruitment:** Unknown.

**State of Stock:** Total biomass large compared with cumulative catch.

**Forecast for 1991/92:**

Option Basis	F	1991 Exploitable Biomass	Catch	F	1992 Exploitable Biomass	Catch	Implications/ Consequences
50 percentile	0.64	1200 <sup>1</sup>	398	0.64	1200	398	Preliminary
5 percentile	0.64		245			245	
50 percentile	0.64	160	53.0	0.64	160	53.0	TACs
5 percentile	0.64		32.7			32.7	

Weights in '000 tonnes

- <sup>1</sup> Assume that 1987/88 survey estimates the exploitable stock in the current years. Exploitable stock assumed to be 100% of 2 year olds and 20% of 3 year olds.

Assessment Summary: *Notothenia rossii*, Division 58.5.1

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings	801	482	21	245	155	287	9812	21	2531
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean <b>F</b> (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (.....)

**Conservation Measures in Force:** Conservation Measure 2/III. Resolution 3/IV.  
Limitation of trawlers allowed on fishing grounds each year. Arrêté N°: 18, 20, 32  
(for details see SC-CAMLR-VIII, Annex 6, Appendix 10, page 290).

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:**

**Forecast for 1991/92:**

Option Basis	<b>F</b>	1991 SSB	Catch	<b>F</b>	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes



Assessment Summary: *Notothenia squamifrons*, Division 58.5.1

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC		5000	2000	2000 <sup>4</sup>					
Landings	2464	1641	41	1825	1262	89	11308	41	4057
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)
- 2 Over period 1981 to 1991
- 3 From VPA using (.....)

**Conservation Measures in Force:** Catch limits set since 1987 (French/Soviet agreement).  
Conservation Measures 2/III; Arrêté 20 and 32.

**Catches:**

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:**

**Forecast for 1991/92:** CPUE very low - maximum = 0.63 tonnes per hour.

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Champscephalus gunnari*, Division 58.5.1

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings (Skif Bank)	0	2625	2	0			2625	0	578
Landings (Kerguelen)	17137	0	157	23628		12644	25848	0	9784
Landings (Combined)					226				
Survey Biomass									
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (.....)

**Conservation Measures in Force:** Conservation Measure 2/III; Arrêté 20; Conservation Measure as for *N. rossii* TACs set under French-Soviet Agreement.

**Catches:** Mainly in north-eastern part of shelf (normal fishing grounds).

**Data and Assessment:**

**Fishing Mortality:** Assumed between 0.42 and 0.49 (from cohort analysis of previous cohorts).

**Recruitment:** A strong cohort was recruited in the 1990/91 season.

**State of Stock:** The strong cohort should remain into the 1991/92 season, and catches should remain high. However there appears to have been a steady decrease in the strength of successive cohorts.

**Forecast for 1991/92:**

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.1

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>	Mean <sup>2</sup>
Recommended TAC									
Agreed TAC									
Landings	459	3144	554	1630	1062	1848	6677	40	1304
Survey Biomass	27200								
Surveyed by									
Sp. Stock Biomass <sup>3</sup>									
Recruitment (age...)									
Mean F (.....) <sup>1</sup>									

Weights in tonnes, recruits in .....

1 ... weighted mean over ages (...)

2 Over period 1981 to 1991

3 From VPA using (.....)

**Conservation Measures in Force:** None

**Catches:** 288 tonnes caught by Soviet trawlers on usual grounds

1 560 tonnes caught by French trawler on new grounds

109 tonnes caught by Soviet longliner

**Data and Assessment:**

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Uncertain. New grounds may or may not be exploiting the same stock as the usual grounds. Longlining appears to exploit the same stock as the trawl fishery. CPUE appears to have declined steadily since 1985.

**Forecast for 1991/92:**

Option Basis	F	1991 SSB	Catch	F	1992 SSB	Catch	Implications/ Consequences

Weights in tonnes

Total catches should be limited to 1 100 tonnes until more is known.

Assessment Summary: *Notothenia squamifrons*, Division 58.4.4

**Source of Information:** This Report

Year	1986	1987	1988	1989	1990	1991	Max <sup>2</sup>	Min <sup>2</sup>
Recommended TAC (Lena Bank)								
Agreed TAC								
Landings (Ob Bank <sup>a</sup> )*	9531	1601	1971	913				
Landings (Lena Bank <sup>a</sup> )*	1977	441	2399	3003				
Landings (Combined <sup>b</sup> )	61	930	5302	3360	1450	575	5302	27
Survey Biomass (Ob Bank)				12700				
Survey Biomass (Lena Bank)								
Surveyed by				USSR				
Sp. Stock Biomass <sup>3</sup>					na			
Recruitment (age...)					na			
Mean F (.....) <sup>1</sup>								

Weights in tonnes, recruits in .....

- 1 ... weighted mean over ages (...)      a      From WG-FSA-90/37
- 2 Over period 1985 to 1991      b      From SC-CAMLR-IX/BG/2
- 3 From VPA using (.....)      Part 2 (Statistical Bulletin)
- \* Calendar Year data

**Conservation Measures in Force:** 2/III, 4/V, 28/IX.

**Catches:** Catches were nearly identical to the TACs. A third set of historical catch data were inconsistent with the previous two reported.

**Data and Assessment:** Data are unreliable but latest catch figures are 7% greater than those used for VPA and TAC calculation at WG-FSA-90. Therefore TAC was probably overestimated.

**Fishing Mortality:**

**Recruitment:**

**State of Stock:** Almost certainly depleted.

**Forecast for 1991/92:**

Option Basis	F	1991 SSB	Catch	F	1992 Biomass	Catch	Implications/Consequences
F <sub>0.1</sub> Ob Bank	0.17			0.13	2949	267	
F <sub>0.1</sub> Lena Bank	0.47			0.13	3454	305	

Weights in tonnes

A low or zero catch should be taken.